

**SOIL EROSION: FARMERS' PERCEPTION AND
CONSERVATION MEASURES IN THE NORTHERN PART
OF TARABA STATE, NIGERIA**

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**FACULTY OF ARTS AND SOCIAL SCIENCES
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PART OF TARABA STATE, NIGERIA**

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ABSTRACT

This study examines farmers' perception of erosion and their conservation measures in the northern part of Taraba State, Nigeria. The objective of this study was to produce knowledge on farmers' perception of soil erosion and their conservation measures. Data were obtained from a survey of 383 farm households' heads during 2014 cropping season. Field observations and in-depth interviews were also held with the farmers, agricultural extension agents, and traditional community agricultural chiefs to obtain additional information. The data obtained were subjected both to descriptive and inferential statistics using the Chi-Square and Spearman correlation analysis. The results of the investigation show that the majority of farmers were aware of and perceived soil erosion by water as a problem constraining crop production in their farm plots and as having increased over the past decade. Farmers perceived intensity of rainfall, types of soil and erodibility and insufficient and delayed fertilizer as the main causes of soil erosion. They considered erosion to be severe mostly when visible signs rills and gullies erosion and change in soil colour appeared in their fields. The results further reveal that the majority of the farmers acquire their farmlands through inheritance. Also, the study revealed that the farmers prefer the steep slope to the lowlands because they try to avoid animals grazing from destroying their crops, less weed invasion and for historical reasons. The majority of the farmers believe that erosion could be halted, and they use a range of measures for water erosion and fertility improvement. These include ploughing across the contour, construction of bunds, construction of ridges, and waterways as major water erosion measures and the use of compost and mulching, intercropping, and use of farmyard manure as the most widely used traditional soil fertility enhancement measures in the research region. However, despite, the used of a range of measures for water erosion and fertility improvement in the study region, the Chi-square test results

showed that farmers' perception of water erosion as a problem is not correlated with their adoption of water erosion control measures ($X^2= 2.252$, $p=0.18$), but, but did invest more in soil fertility measures ($X^2= 383.00$, $p= 0.000$). The results further showed that those farmers who identified increased in water erosion and depletion of soil fertility over the decades were not significantly associated with their level of adoption in soil erosion and fertility measures, ($r=-0.027$, $p=0.60$) and ($r=0.036$, $p=0.482$) respectively. Similarly, the results further revealed that there are few extension agents in the study region and visits and services given to farmers are insufficient, infrequent and irregular. The research concludes that under the present condition of the study region, the biophysical examination of the farmers' fields is integrated into future studies to provide empirical evidence about the soil fertility status of the cultivated fields and adoption of the recommendations.

ABSTRAK

Tujuan kajian islan untuk mengkaji persepsi petani terhadap hakisan tanah dan langkah-langkah pemuliharaan yang dilakukan di utara Taraba State, Nigeria. Data diperolehi daripada 383 isirumah pada musim tanaman tahun 2014. Pemerhatian lapangan dan temubual telah dilakukan terhadap petani, pegawai pertanian dan ketua masyarakat tradisional untuk mendapatkan maklumat kajian. Data yang diperolehi telah dianalisis dengan kaedah statistik deskriptif dan inferensi menggunakan analisis korelasi Chi-Square dan Spearman. Hasil kajian mendapati bahawa majoriti petani menyedari hakisan tanah oleh air sebagai masalah yang mengekang pengeluaran tanaman di plot ladang mereka dan ia telah meningkat sepanjang dekad yang lalu. Petani menyedari keamatan hujan, jenis tanah, tahap hakisan, kelewatan pembajaan dan jumlah baja yang tidak mencukupi sebagai punca utama hakisan tanah. Petani menganggap hakisan telah menjadi teruk apabila tanda-tanda rills dan galur hakisan perubahan warna tanah mula wujud di plot pertanian mereka. Kajian mendedahkan bahawa majoriti petani memperoleh tanah ladang mereka neruk noyong. Hasil kajian juga mendapati bahawa petani lebih suka bertani di cerun curam berbanding kawasan tanah rendah kerana ia selamat dari haiwan meragut yang memusnahkan tanaman mereka serta kurang serangan rumpai. Majoriti petani yakin bahawa hakisan air boleh dibendung. Mereka menggunakan pelbagai langkah untuk mengatasi hakisan dan peningkatan kesuburan, ini termasuk pembajakan merentas kontur, pembinaan ban, rabung dan laluan air sebagai langkah utama mengawal hakisan air. Petani menggunakan baja kompos dan sungkupan, tanaman selingan dan menggunakan baja sisa ternakan sebagai langkah penambahbaikan kesuburan tanah tradisional yang digunakan secara meluas di wilayah ini. Walaupun, pelbagai kaedah digunakan untuk mengawal hakisan air dan peningkatan kesuburan di rantau kawasan ini dilakukan, keputusan ujian Chi-square menunjukkan

bahawa persepsi petani terhadap hakisan air tidak mempunyai kaitan dengan langkah-langkah kawalan hakisan air yang diamalkan ($X^2 = 2,252$, $p = 0.18$), tetapi kumpulan petani ini didapati melabur lebih banyak dalam langkah-langkah meningkatkan kesuburan tanah ($X^2 = 383.00$, $p = 0.000$). Keputusan lanjut menunjukkan bahawa golongan petani yang mengenalpasti wujud peningkatan hakisan air dan pengurangan kesuburan tanah sejak beberapa dekad mempunyai hubungan tidak signifikan dengan tahap penerimaan hakisan tanah dan kesuburan langkah-langkah, ($r = -0,027$, $p = 0.60$) dan ($r = 0.036$, $p = 0,482$). Hasil kajian juga mendedahkan bahawa terdapat pegawai pertanian di kawasan ini namun lawatan dan perkhidmatan yang diberikan kepada petani tidak mencukupi, tidak kerap dan tidak teratur. Kajian ini menyimpulkan bahawa berdasarkan situasi semasa di kawasan kajian, penilaian biofizikal kawasan pertanian harus disepadukan dalam kajian masa depan untuk menyediakan bukti empirikal tentang status kesuburan pertanian dan adaptasi cadangan pembangunan.

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LIST OF SYMBOLS AND ABBREVIATIONS

FAO	:	Food and Agricultural Organization
GDP	:	Gross Domestic Product
GEF	:	Global Environmental Facility
Ha	:	Hacters
HHs	:	House Holds
LGA	:	Local Government Areas
N	:	Naira
NPC	:	National Population Commission
SPSS	:	Statistical Package for Social Sciences
SSA	:	Sub-Sahara Africa
TADP	:	Taraba Agricultural Development Programme
USD	:	United States Dollar

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CHAPTER 1: INTRODUCTION

1.1 Background of the study

Nigeria is a developing country that is facing diverse environmental problems. Soil erosion is one of the major environmental problems affecting the living condition of the peasant farmers. This remains the biggest challenge to the economic development of the country that is basically agrarian as it lowers yield and halts its growth. Factors including poor land use management practices, rapid population growth, and inequitable land tenure were cited as the major causes of soil erosion, besides intensity of rainfall, soils and terrain nature (Abayomi, 2012).

Although many regions of the country have been facing severe soil erosion, the situation is particularly more pronounced in the ecologically vulnerable areas of the northeastern part of the country. According to Okoye (2009), the northeastern region has the highest susceptibility rates of erosion in Nigeria, because its soils are mainly light and susceptible to erosion. Eventhough, the region, receives a relatively low amount of rainfall, the rains normally have large raindrop sizes and are of high intensities, usually commencing when there is little or no vegetation to offer protection to the soil. While the slopes of the highlands which dominate the region accelerate run-off which subsequently encourages soil erosion.

Unfortunately, despite the vulnerability status of the northeastern region to soil erosion, recent agricultural activities in the sloppy areas of the northern part of Taraba State have increased, however, unlike in the other areas in the humid tropic and subtropical regions where the recent human impact of agricultural use on hill slope areas has increased because of population pressure and the influence of developmental activities, this was, while, flatland areas exist. Hence, the question remains, why are farmers in this region engaged in this practice? Could this mean they do not understand

the magnitude of soil erosion problems prone to hill slopes? An attempt to answer these questions prompted this present research.

Although, several types of researches have been conducted on on-farm soil erosion in Nigeria generally, and in the study region in particular, but most of them have been focused on the quantitative assessment of the magnitude of soil erosion. Very few studies focused attention on the qualitative assessment of soil erosion using farmers' perception of soil erosion and their conservation measures. Some experts believe that due to the insidious nature of pervasiveness of soil erosion, farmers may be ignorant of its seriousness and reluctant to response (Amsalu & de Graaff, 2006; Dalton, *et al.*, 2014). While, many issues and decisions on on-farm soil erosion and its effects cannot be addressed solely through technical expertise because they need not only biophysical examination but also, perceptions and soil conservation understanding (Boardman *et al.*, 2003). Thus, this forms the thrust of this study.

Farmers' perceptions of soil erosion in the form of water erosion and fertility depletion and their conservation measures are the most significant social factors that determine the degree of understanding of soil erosion and its effects (Okoba & De Graaff, 2005). They influence the farmers' levels of support and investment in the context of solving soil erosion and fertility depletion problems by adopting alternatives and conservation practices (Hammad & Borresen, 2006). Moreover, perceiving soil erosion as a problem by farmers is an important determinant of soil conservation (Vigiak *et al.*, 2005). Bewket & Sterk (2002), had earlier reported that any conservation program might not be successful without prior understanding and consent of the concerned stakeholders, the farmers.

Similarly, as indicated by Kerr and Pender (2005), understanding changes associated with varying and dynamic land use system from the farmers' perception is essential if

proper intervention measures are to be advanced and long-term management strategies are to be successfully adopted. Moreover, most farmers, particularly the untrained ones, decide on how to use their land in line with their objectives and understanding of soil, ignoring any theoretical basis. Therefore, analyzing farmers' perception will help in identifying problems and workable solution that are necessary requirements for successful conservation measures.

Additionally, farmers' perception of soil erosion and their responses to soil degradation in the form of water erosion differ from area to area and from household to household depending on the prevailing ecological, economic, and sociocultural characteristics. Therefore, the results from elsewhere cannot extrapolate to the northern part of Taraba State.

This study investigates farmers' perception of soil erosion and their attempts at soil conservation. A study like this will be able to reveal a wide range of variation in the ability of the farmers, and to understand the manner in which human being intervenes in such system and alternatively on how well to manage soil erosion problems the canal factor of which is/ are anthropogenic.

1.2 Statement of the problem

Soil erosion has been recognized as the major environmental problem in Nigeria in general and in the northeastern region in particular. It is usually manifested in the informed of rills/gullies and fertility decline. It reduces soil productivity and increases vulnerability to drought and consequently food insecurity. Hence, this unveils danger of soil erosion and the needs for a concerted effort in the fight against its effects.

In most regions or communities across the country, productivity of land is safeguarded to feed the ever-increasing population just at a time when agricultural efforts are focused on increasing crop yields. Consequently, in the study region, farmers

are farming on the erosion prone areas such as hill slopes as well as flooded plains disregarding the flatlands provided by nature. Given this ominous development, understanding farmers' perception of soil erosion and their conservation measures remain essential to any program to improve food security and development.

Although, many researches have been conducted on on-farm soil erosion in Nigeria generally and in the study region, in particular, few or no study has been conducted to investigate farmers' perception of soil erosion and their conservation measures. Moreover, such few studies are scanty, far between, and concentrated in areas surrounding major research institutes and our older universities. The main reasons for these scanty and skewed efforts are that most soil erosion studies were performed off-farm. Few research projects were on-farm and included the participation of farmers. In addition, soil erosion studies in Nigeria have not been given the requisite research attention and funding. Consequently, most soil erosion studies are self-sponsored by lecturers to gain promotion.

Perhaps the reasons why such few studies could not shed much light on the nature of on-farm soil erosion and conservation is that the studies are essentially either on an experimental assessment of the magnitude of soil erosion, or are quantitative in nature derived from experimental plots. Birmingham (2003), stressed that such studies hardly provide an inhabitant perception of soil erosion and their conservation measures. While, perceiving soil erosion, as a problem by farmers is an important determinant of conservation practices, which is vital to the achievement of food security, poverty reduction, and environmental sustainability. In addition, to providing a guide to researchers and agricultural extension personnel in refining their research and conservation agenda to respond to the needs felt by farmers.

Moreover, the few research projects on the inhabitant perception of soil erosion and conservation in Nigeria are more focused on the southwestern and eastern parts of the

country, which have a different geographical settings from the study region. The only references to on-farm soil erosion and conservation based on farmers' perception in the northern part of Nigeria, especially, the north-eastern part to which this study region belongs to the knowledge of the present researcher are those of Adebayo & Tukur (2003); Hoffmann *et al.*, (2001); Thapa & Yila (2012), even so all these researchers independently used only sole locations (villages) in north-eastern Nigeria for their studies and such studies are not in themselves representative of northern part of Taraba State of Nigeria. Hence, it is glaring that the northern part of Taraba state is a neglected area in terms of research on the inhabitant perception of soil erosion and conservation under agricultural land. There is no doubt, therefore, that the present study is carried out in the study region to bridge this existing research gap. Moreover, the study will complement the existing similar few studies from other parts of the country.

Furthermore, in face of the rapidly growing population and people needs food to survive, while soil erosion remaining the single largest threat to soil productivity and hence food productivity and food security, researchers such as Kiage (2013); Lal (2009); Pimentel (2006), and notable institutions such as FAO (2011); FAO (2013); World Bank (2006), have challenged researchers to venture into assessing soil erosion and conservation under agricultural lands for sustainable food production in the world and sub-Saharan African countries in particular and Nigeria inclusive. There is no doubt, therefore, that this study on farmers' perception on soil erosion and their conservation measures in the northern part of Taraba state, Nigeria, is timely and highly pertinent to bridge this existing gap at a local level. Given that, local scale studies such as this are critical to the design of regional appropriate soil conservation and economic development interventions. Thus, the present research is targeted towards generating a base-line data and /or information for further similar research works in the study region.

It was, therefore, the aim of this research to investigate farmers' perception of soil erosion and their soil conservation practices, with a view to gain a better understanding of farmers' reason for cultivating hill slopes, while, there were flat land areas in the study region. This desire was connected with the agricultural, residential, engineering and industrial support potentials of the study region.

1.3 Research Aim

The aim of this study is to produce knowledge on farmers' perceptions of soil erosion and their soil conservation measures in the northern part of Taraba State, Nigeria.

1.4 Research objectives (RO) and Research questions (RQ)

RO1. To examine farmers' perception on soil erosion

- i. *RQ.* What are the socio-economic characteristics of farmers in the study region?
- ii. *RQ.* How farmers do perceive soil erosion by water and their preferences for cultivating hill slopes in the study region?
- iii. *RQ.* What are the farmers' perceived causes, indicators, effects and consequences of soil erosion in the study region?
- iv. *RQ.* How farmers do perceive the trend of water erosion over the last ten years in the study region?

RO2. To assess farmers' soil conservation measures for controlling soil erosion by water and fertility depletion.

- i. *RQ.* What are the existing traditional knowledge, techniques, and practices used by farmers to halt soil erosion by water, and the depletion of soil fertility in the study region?

- ii. *RQ*. How farmers do perceived the existing traditional soil conservation methods in the study region?
- iii. *RQ*. How do farmers' perceived the trend of soil fertility depletion over the last ten years in the study region?

RO3. To evaluate farmers' adoption of soil conservation measures in the study region

- i. *RQ*. What types of services are needed by farmers to control soil erosion and fertility depletion in their farm?
- ii. *RQ*. Are the services giving to the farmers by extension agents adequate, timely, and frequent to control soil erosion and fertility depletion?
- iii. *RQ*. What is the relationship between farmers' adoption of soil conservation measures and their perception of water erosion and fertility depletion as a problem?
- iv. *RQ*. What is the relationship between the farmers' perceived trend of water erosion and soil fertility depletion and their level of adoption of soil conservation measures?

1.5 Research Hypothesis

Two hypotheses for farmers' perceptions of water erosion and soil fertility versus of adoption of soil conservation were developed

- i. If farmers are aware and perceive water erosion as a problem, they are much more likely to embrace the practices for soil erosion by water control measures.
- ii. If farmers perceive depletion of soil fertility as a problem, they are more likely to adopt fertility control measures.

Two hypotheses for farmer perceptions of the trend of soil erosion and fertility depletion versus the level of adoption of soil conservation measures were developed

- i. If farmers perceived that water erosion is increasing over time, they increased the level of adoption of practices for water erosion control measures.
- ii. If farmers perceived soil fertility degradation over time, they will increase the level of soil fertility control measures.

1.6 The study region

The study was limited to the northern part of Taraba state, which is located between latitudes $6^{\circ}30'$ and $9^{\circ}36'$ N and longitudes $9^{\circ}10'$ and $11^{\circ}50'$ E. The study region consists of six local government areas that were made up of six-two districts, and a range of between 21-47 major villages and approximately 305 to 874 households in each district and villages respectively. The study region has a total surface area of $16,719\text{km}^2$, a total population of 785,912 inhabitants in 2015, with a projected growth rate of 3.1 percent per year (NPC, 2016). Bounded by the research objectives and questions, and its spatial-temporal distribution, the study region was selected as a case study. A case study approach helps to contextualize the biophysical and socioeconomic factors that cause soil erosion in a particular locality. The choice of the study region as a case study was based on four main reasons: -

- i. Firstly, it is a neglected area in terms of research on inhabitant perception of soil erosion and conservation under agricultural lands.
- ii. Secondly, it represented the more severely degraded region in Taraba State.
- iii. Thirdly, there is comparatively good information regarding physical, environmental attributes such as topography, climate, soils, and the socioeconomic environment.
- iv. Fourthly, the significance of the study region in agricultural production in Taraba state in particular and Nigeria in general.

1.7 Scope of the study

The study mainly focuses on an investigation of farmers' perception of soil erosion and their conservation measures in the northern part of Taraba state, Nigeria. This was because the research region is a neglected area in terms of this study, while; the on-farm erosion phenomenon in the region requires an immediate understanding and solution in order to enhance agricultural productivity and soil fertility. The study was also limited to the accelerated soil erosion by water under agricultural lands; soil erosion by the wind was not included. This was because the effects of wind erosion are limited. The inhabitant who owns or have access to land; landowners and tenant inhabitants only were included as a sample, the landless inhabitants, who may or may not have a different perception of the problems were not included in the sample. Thus, the study mainly focuses on the issues mentioned above in the northern part of Taraba state due to the resource inadequacy and constraints.

1.8 Organization of thesis

This study is organized and presented in seven chapters. Chapter one as an introduction, chapter two as a theoretical framework and working model chapter, chapter three as research methodology, chapter four as the study region, chapter five as results and interpretation, chapter six as discussion and chapter seven as a summary, conclusion, and possible recommendation based on the results of the study.

Chapter one

Is an introductory chapter, it outlines a general background of the study along with a statement of the problem, the aim, objectives, and the specific research questions being answered. The chapter also consists of a brief on the study region, conceptual framework, research scope, and summary of what the thesis intends to do.

Chapter two

This chapter concerns itself with the review of relevant literature, which forms the basis for developing this study, in terms of research goals and interest. Related studies that have examined the specific aim and objectives of the research (farmers' perception of soil erosion and conservation measures) were reviewed. Also, the conceptual framework within which the study was undertaken is presented.

Chapter three

This chapter discusses the methodology of the study. Here, the types of data needed for this research, where and how they were sourced, the statistical analyze that were employed and the methods of results presentation are discussed.

Chapter four

In this chapter, the study region is examined. The major issues discussed include the geographical setting of the study region, which includes its location, and extent, physiographic characteristics, in terms of its relief, drainage, climate, soils, and vegetation, as well as the people, and their economic activities and land uses.

Chapter five

This chapter focuses on the presentation and interpretation of the results of the research carried out on this topic. The final model developed from this study is also presented here.

Chapter six

Is the discussion chapter and it highlights the relationship between the research findings in the study region and what has been found in the literature.

Chapter seven

This chapter presents the summary and conclusion of the study and possible recommendations based on the implications of the findings of the study.

University of Malaya

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This section contains the review of the previously related literature on the various sub-themes of the study, the conceptual framework within which the study was undertaken, the methodologies used and the factual findings of previous studies.

2.2 Concept of soil erosion

The soil has been under assault from human and non-human agencies for thousands of years (Bindraban *et al.*, 2012; Eswaran *et al.*, 2001). However, the precise type, and the magnitude, as well as the duration of the assault, varied in space, sometimes enormously. Similarly, there have been many variations in the socioeconomic and spatial expression of, and the attempted remedies for the impact of these assaults on the soil. The best known or, at least, the most talked about, the result of the assaults on the soils is soil erosion (Lal 2001).

Soil erosion as defined by Bryan (2000); Nyakatawa *et al.*, (2007), from the geomorphological viewpoint, is a form of soil degradation or soil transformation into sediments usually caused by wind and water. As stated by Lal (2001), it is a three-phases process consisting of the detachment of individual particles from the soil mass, their transport by erosive agents such as running water, wind, ice, gravity under the influence of a defined force, and finally its deposition when sufficient energy is no longer available to transport the particles. Thus, resulting in either a geologic (natural erosion) or an accelerated, (man and animal-induced) erosion felt as on-site and /or off-site impacts. While, from the human point of view, as defined by Meshesha *et al.*, (2012); Pimentel (2006), it is a gradual decline in soil productivity quantitatively or qualitatively caused through its abused by human action. The gradual reduction, according to them may be through the physical removal of soil or decline in soil fertility

without actual loss of soil or a combination of both. Soil erosion is one of the processes of soil degradation, which reduces the productive capacity of agricultural lands and lead to desertification.

The above definitions implies that soil erosion is a gradual reduction in soil qualities quantitatively or qualitatively and occurred in a three phase processes, first with soil particle detachment, then transportation of the detached particles by agents of denudation, such as water and the wind and finally its deposition resulting into either a geologic (natural erosion) or an accelerated, (man and animal-induced) erosion felted as on-site and /or off-site impacts. The natural form of soil erosion is so slow and imperceptible; it is often considered as normal erosion and is usually of little concern from the soil quality point of view. This is because as stated by Nyakatawa *et al.*, (2007), its rate is low, and the soil loss can be replaced through the natural process. While the accelerated form of soil erosion is often triggered by the activities of man such as his choice of sites, over tilling, shifting cultivation, and inappropriate agricultural practices (Kiage 2013; Mullan 2013). Its loss rate is must faster than regeneration, resulting in “deficit spending” of the topsoil.

An accelerated form of soil erosion under agricultural lands has both on-site and off-site effects. Munodawafa (2007), stated that the on-site effect can be reflected in reduced soil and crop production potentials, lower surface water quality and damaged farm networks, while, the off-site effects include siltation of reservoirs, eutrophication of ponds and lakes, pollution of water. This means that despite the significant contributions of soil erosion edaphically as a process of soil formulation on which agriculture is based (Nyssen *et al.*, 2009; Vlek *et al.*, 2010), geomorphologically, as the basic process of landforms modifications (Junge *et al.*, 2009; Tefera and Sterk 2010), and agriculturally, as a medium for providing fluvial soils when eroded soil materials

are deposited either by water or the wind. Soil erosion has remained the major root cause of soil degradation and the most threatening environmental problems which imposed on site cost to individual farmers in terms of reduced yield and off-site cost to society as a result of externalities (Figure 2.1). Lal (2009a), urged that it determines the productive capacity of soils and it affects global climate through alteration in water and energy balance and disruption in a cycle of carbon, nitrogen, sulphur and other elements.

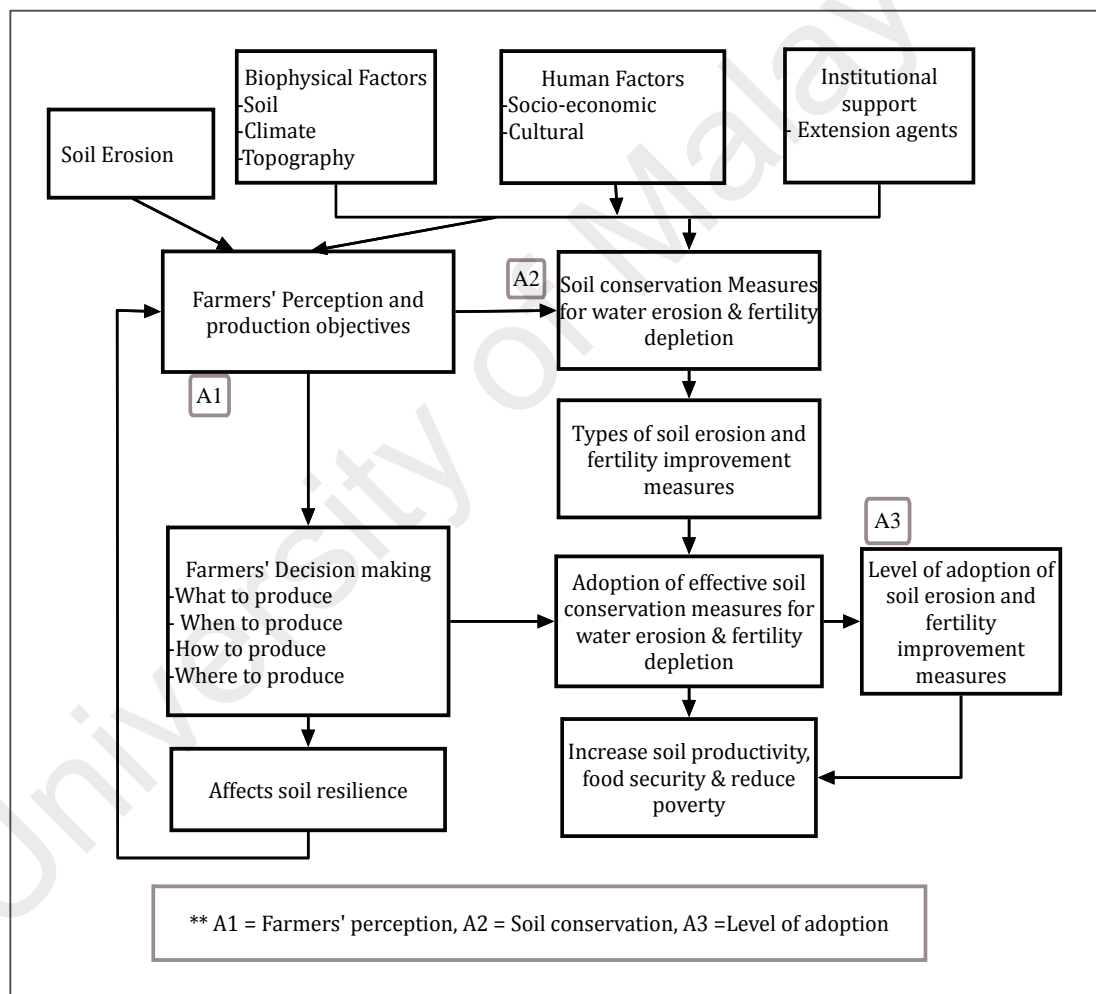


Figure 2.1: Conceptual model: Farmers' perception of soil erosion and their conservation measures

2.3 Soil erosion in the World

Empirical findings in the literature have put the total surface area of the earth to cover 510 million square kilometers or $5.1 \times 10^8 \text{ km}^2$. Of this proportion, 361 million square kilometers (constituting 70.8%) is covered with water bodies and 149 million square kilometers (forming 29.2%) made up the total land surface. Of the total earth surface (14.9 billion hectares), One-quarter (3.7billion) is a desert, 2.4 billion ha is covered with mountain terrain, 3.9 billion ha is made up of ice (mass glacier), and 1.7 billion ha is too arid not suitable for agriculture. Only 3.2 billion hectares of land are cultivable. Out of this proportion (3.2 billion ha), 1.36 billion hectares (42%) were estimated to have been put under cultivation while, the remaining 1.84 billion ha (58%) was considered unfavorable for cultivation due to climatic and terrain problems (Eswaran et al., 1997). This suggests that the global total cultivable lands are limited.

However, with the limited cultivable lands and finite soil resources, much of the world agricultural land have been exposed to severe soil erosion of various degrees. Poor land use management practices, deforestation, topography, the climate in terms of rainfall and wind are the immediate causes of soil erosion (Lal 2001). Population pressure, insecure land tenure, inappropriate and/or inadequate soil conservation technologies are they underlying or distant causes, and most of these are further influenced by various government policies.

Over 80 percent of the global, today's cultivated land base of approximately 1.5 billion hectares has been ravaged by soil erosion (Fuchaka *et al.*, 2002; Kimaro *et al.*, 2008; Mullan, 2013; Obalum *et al.*, 2012). The human-induced causes of soil erosion were projected to account for about (75%) 1.2 billion hectares (Lal, 2006; Obalum *et al.*, 2012). Soil erosion by water, at a global scale, is the major soil degradation process under agricultural lands (Bakker *et al.*, 2007; Kagabo *et al.*, 2013). According to Bakker

et al., (2007), soil erosion affects about 1094 million hectares or roughly 60% of the agricultural lands that experienced the human-induced degradation. Pimentel (2006), estimated that nearly one-third (about 12×10^6 ha) of global arable land (slightly less than the size of the state of Mississippi) has been lost by erosion annually during the last few decades. He further predicted the loss rate to continue at more than 10 million hectares per year. The average annual irretrievable loss of productive land through water erosion was projected to be at 6 million hectares every year (FAO, 2011; Haregeweyn *et al.*, 2015). Without an adoption of better soil management practices, many scholars, including Chen *et al.*, (2007); Daniel *et al.*, (2007); Zaidel'man, (2009), have projected that; one-third of the world's arable land will be destroyed by the year 2020, and soil productivity in many developing countries including Nigeria, where population growth is the highest in the world, while, its soils more highly weathered with low inherent fertility will be reduced by one-fifth by 2020.

2.4 Soil erosion in Africa

Much of the African continent, which account for about 39%, of the world's land surface have been facing serious soil erosion problems of various degrees caused by both natural and human factors as well as its consequent negative environmental effects. No portion of only about 3% of the global land surface considered as prime or class one (1) fall into the continent (Sanchez & Swaminathan 2005). Most of the continent's cultivated lands have been classified as unproductive as a result of the revenge of soil erosion, especially, during the last forty years.

The loss of soil through soil erosion is the single most important soil degradation process affecting the productive capacity of the continent agricultural soil and rendering it vulnerable to degradation (Kiage 2013). In other words, soil erosion is the most ubiquitous cause contributing to agricultural soil degradation and challenging

agricultural productivity and economic growth in the continent. It has been noted by Bewket (2007); Junge *et al.*, (2009) that the apparent increase in the food insecurity and poverty that engulf most sub-Saharan African countries particularly Nigeria is the consequences of soil erosion. Pimentel (2006), has earlier argued that the reduction in water availability due to soil degradation informs of soil erosion in the continent is a major threat to food security and the environment. This means that the severity of the erosion problem in the African continent is widely appreciated.

The continental dimension of soil degradation is alarming with about 35% of the continental land surface being affected and more than 15% of the continental cultivated land mass were degraded (Pimentel & Burgess, 2013; Scherr, 1999). More than 80% of soil degradation is due to soil erosion, out of which 55.7% has been caused due to water-induced soil erosion, 28% by wind erosion, while other factors such as chemical and physical interference account for the remaining 12.1% and 4.2% respectively (Meshesha *et al.*, 2012). No wonder Lal (1988), earlier stated that the natural productivity of many soils in most African countries has been reduced by 8-100%, because of erosion and in some areas the productivity of eroded soil cannot be restored even with the heavy application of fertilizers and other inputs. This means that the apparent increase in the food insecurity and poverty that engulf most sub-Saharan African countries, particularly Nigeria is the consequences of soil erosion.

The number of studies on the relationship between soil erosion and the soil productivity loss in Africa though limited. Available data show that irreversible soil productivity losses from water erosion appeared to be serious on a national scale in Algeria, Morocco and Tunisia (North Africa), Ethiopia, Kenya and Uganda (East Africa), Nigeria, and Ghana (West Africa) and Lesotho, Swaziland and Zimbabwe (South Africa). It is estimated that losses in productivity of cropping land are in the

order of 0.5-1% annually, suggesting productivity loss of at least 20% to 40% over the last 40 years. This means that the annual rate of soil loss on cultivated fields in most African countries is higher than the annual rate of its soil formation. Hence, this could be the reason why many scholars, including Ananda and Herath (2003); Bindraban *et al.*, (2012), urged that without a concerted effort in the fight against soil erosion, the situation is bound to worsen as demand for food is expected to increase up to five-fold by 2030, while, the per capital arable land area dedicated to crop production was projected to be shrinking because of population growth and soil erosion. It has also been noted by Boj  (1996), that the severity of past erosion in Africa has caused a yield reduction of 2 to 40% per year. He further projected that; if the present trend of soil erosion in most African countries continues unabated the yield reduction by 2020 maybe 16.5% -40%.

Soil erosion by water is a primary agent of degradation. According to Kiage (2013); Nyssen *et al.*, (2009), the severity of soil erosion by water in Africa as elsewhere in the tropic is dependent on particularly the factors of soil referred to as erodibility that can be quantitatively evaluated as the vulnerability of the soil-to-soil erosion in given circumstances. The climate is another factor that might cause soil erosion especially the effects of rainfall on the soil (Ziadat & Taimeh 2013). This is determined by erosivity that is the property of rainfall that can quantitatively be evaluated as the potential capacity of rain to cause erosion in given circumstances. Another property is that of Landform, and it includes the length, steepness of slopes and their uniformity of shape (Ziegler *et al.*, 2006). Lastly, is of course management, that is a wider term covering all the factors directly under man's control such as his choice of land use sites, choice of crop types, and methods of crop production entrenched from his perception and awareness of soil erosion processes, and impacts (Birmingham, 2003; Grimaldi *et al.*, 2013). Soil erosion is also caused as a result of lack of efforts in conservation. Thus, soil

erosion in most Africa countries including Nigeria largely remains a problem to be tackled at ensuring food security, poverty reduction, and environmental sustainability.

2.5 Soil erosion in Nigeria

Soil degradation in the form of soil erosion is the main environmental problem in Nigeria (Essiet, 1990; Okoye, 2009). The degradation mainly manifests itself in terms of land where the soil has either been eroded away and/or whose nutrients have been taken out to exhaustion without replenishment. The farming system and farming practices in Nigeria are characteristically of the subsistence type (Kolawole, 2013; Ndaeyo *et al.*, 2001). This means that the majority of the farmers are subsistence-oriented.

In Nigeria, like most African countries, despite, the highly diverse and favorable soil and climatic conditions in certain ecological zones, soil productivity, and food security has remained variable and indeed on the decline, especially in the northern part of the country (Adebayo & Tukur, 2003). Soil productivity and sustainable food production and food security in this part of the country are thus threatened by soil erosion (Adebayo & Tukur, 2003). As studies revealed rapidly increasing human population, insecure land tenure, extensive deforestation, improper farming practices and lack of appropriate conservation technologies, besides high intensity of rainfall, soil, and terrain nature, aggravated and favoured erosion problem, especially where the vegetation cover is reduced or removed (Thapa & Yila, 2012; Tukur *et al.*, 2004).

Soil erosion by water is the main agent of erosion in agricultural lands in Nigeria (Adebayo & Tukur, 2003). The impact of soil erosion problem in Nigeria, and indeed the study region has led to the degradation of agricultural land and the consequent reduction in their production, thus exposing the population to food insecurity. It has also been noted by Chukwuka & Omotayo (2009); Henao & Baanante (1999), that Nigeria is

among the nations with the highest estimated rates of soil nutrient depletion in sub-Saharan Africa, which reduces productivity and increases vulnerability to drought and increase food insecurity. This means that soil erosion by water is the main agent of soil degradation in agricultural lands that constitutes a severe threat to the peasant farmers' means of livelihood and the Nigerian economy that is basically agrarian.

In the same vein Abayomi (2012), have also discussed that erosion is reducing the country's food production by 1-5 percent annually and projected that by the year 2020 some 2.5 to 4.5 million farmers in Nigeria might be affected. A similar study conducted by Junge *et al.*, (2008), estimated soil erosion to cost Nigeria on average 2.5 percent of soil productivity annually from that of the 2000 productivity level. In addition, FAO, (2013) also estimated that erosion has cost Nigeria 5-17% of its Gross Domestic Product (GDP) between 2000-2010, and projected an increased GDP loss of about 23 to 49% by 2025. This shows that the trend of the impact of soil erosion by water is increasing from time to time rapidly in the country. The economic cost of soil erosion in Nigeria is estimated to be around USD 1.5 billion per year (Junge *et al.*, 2008). According to Junge *et al.*, (2008) the minimum annual cost of soil erosion ranges between 2 and 4 percent of the Nigerian national agricultural GDP. This also clearly shows the extent to which soil erosion is a contributing factor to the country's structural food insecurity problem, and the need for a concerted effort in the fight against its effects.

Furthermore, Essiet (1990); Okoye (2009); Salako *et al.*, (2006), have discussed that the severity of soil erosion in Nigeria varies from region to region, with the northeastern region of the country having the most severe level, the northern part of Taraba state inclusive. Studies by Ray & Yusuf (2011); Tekwa & Usman (2006), revealed that agricultural lands have been experiencing declining soil fertility and crop productivity

loss mainly because the soil is light and susceptible to erosion. Although, the region receives a relatively low amount of rainfall, the rains normally have large raindrop sizes and are of high intensities, usually commencing when there is little or no vegetation to offer protection to the soil. While the slopes of the highlands which dominate the region accelerate run-off which subsequently encourages soil erosion. These conclusions concurred with the explanation earlier provided by Hurni (1988), that soil erosion is more severe in soils that are shallow, with poor quality subsoil, which does not have thick topsoil, particularly those on the hilly slopes. Similarly, Ericksen & Ardón (2003); Kagabo *et al.*, (2013), have urged that the apparent increase in soil erosion over the past generation is not the result of a decline in the skills of farmers but rather the result of the extension of agricultural activities on hill slope areas. This means that increasing agricultural activities on hill slope areas accelerates loosening of topsoil and hence, soil and crop productivity lost.

With reference to the study region, soil erosion manifest in the form of reduced soil productivity and physical degradation in the form of rills and gullies across the region, but at varying rate and level of intensity. It assumes the catastrophic dimension within a very short time in those areas such as hill slopes and flooded plains where land are used beyond its capabilities and by those methods of soil and crop management that are ecologically incompatible (Adebayo & Tukur, 2003; Malgwi & Abu, 2011). With regard to this, Shankarnarayan (1995), had earlier stated that soil erosion occurs in various forms depending on land use, but the mountainous areas and sloppy fields, where agriculture is practiced are especially more prone to severe erosion hazards following excessive deforestation, faulty cultivation, overgrazing and developmental activities.

Empirical investigations of the magnitude of accelerated soil erosion by water problem in northern Nigeria, to which belong the study region, revealed that accelerated soil erosion by water has affected 53,028 km² (70%) of croplands, with over 50% completely rendered useless for cultivation. In Nigeria as a whole, more than 50% (40 million hectares) of the cultivated land is under medium to long-term fallow as a result of the ravages of erosion. The magnitude of soil erosion as observed by Pimentel (2000), result from the wrong choice of sites and poor cultivation methods, which pose a serious threat to the natural resource base and bring an area even to a point of no return from irreversible degradation. This is because contour plowing often practiced especially on the marginal land leads to enormous soil loss and fertility decline (Hudson & Cheatle, 1993).

However, Jnr (2014) has noted that the eroded soil, when deposited somewhere else, can constitute a big nuisance. For one, it submerges fertile arable land or crops as well as causing blockages in irrigation channels. Thus making access to agricultural field difficult, these deposited materials could also close up drainage-facilities that may result in flooding. Hence, this shows that the magnitude of soil erosion is alarming and constituting a serious threat to the economic development of the region that is basically agrarian.

Similarly, the average soil loss due to water erosion of the region is presently estimated at between 158.8 and 450 tons/ha/year, with over 80% of the estimated value annually coming from cultivated fields, which accounts for only 23.5 % of the total area (Pimentel 2000). When ordinarily erosion rates in the region that exceed 5 to 40 tons/ha/yr are considered problematic (Olowolafe, 2008). Moreover, soil reformation is extremely slow and non-renewable over the human time-scale (Koch, 2013; Banwart, 2011; Lal, 2009). The same studies further predicted that the situation is bound to

worsen if the trend of soil erosion continues unabated, and one-fifth will reduce soil productivity in the region by the year 2020.

Hudson, (1989), have earlier noted that, soil loss rates on cultivated lands that range from 10 to 100 t/ha/yr, are evident, and are exceeding soil formation rate by at least ten times in most of the world's major agricultural nations (based on a soil formation rate of about one t/ha/yr). This could be the reason why NEST (1996), concluded that in the northern Nigeria, especially in the research region, erosion problems have culminated in a significant loss of soils and consequent decrease in the nutrient capacity, moisture retention capability, organic matter content and depth of the soil which have contributed to the decline in agricultural production. In the same vein Olatunji, (2003); Yusuf & Ray (2011), have also discussed that such impacts of soil erosion often translate into low yield, reduced grazing land for livestock, famine, low standard of living, and decrease in availability of fuel wood, migration of rural dwellers, food insecurity, and poverty.

2.6 Causes of soil erosion on agricultural lands

Soil erosion by water is a complex historical phenomenon governed by several factors (Bindraban *et al.*, 2012; Sharda *et al.*, 2010). These factors of soil erosion on agricultural lands are not universal. They vary from region to region and depend on the complex interaction of a number of factors. They dynamics are broadly divided into two main causes or factors, namely physical or natural and anthropogenic or human factors.

The Physical factors include natural agents such as the soils (Kaiser 2004), climate; temperature and rainfall (Ziadat & Taimeh, 2013), vegetation (Midmore *et al.*, 1996), and landforms; position, slope steepness, and slope length (Ziegler *et al.*, 2006). While, the anthropogenic factors include the whole range of factors directly under man's control such as the choice of land use sites, cropping system, cultivation system

Kirkegaard *et al.*, (2013); Knowler & Bradshaw, (2007); Lal (2007), as well as land tenure systems and policy distortions (Knowler, 2007; Place, 2009).

In most empirical studies, soil erosion on agricultural lands is attributed to a combination of a number of natural and anthropogenic factors. However, very many others investigations, including those of Birmingham (2003); Kagabo *et al.*, (2013); Lal (2007), concluded that soil erosion is an artifact of inappropriate soil resources management by farmers. Besides, Nyssen *et al.*, (2009), Yusuf & Ray, (2011), have attributed the occurrence of widespread soil erosion on agricultural lands mainly to the impact of socio-economic and cultural forces driven by demographic variables such as rapid population growth, density, migration, land tenure, customs, indiscriminate intensive and extensive land use with none or low consideration for resilience or replenishment. It may be against this background that Makhanya (2004), discussed that the natural factors take advantage of the anthropogenic factors to exacerbate soil erosion; otherwise, they are agents of adjustment and readjustment, in space and time, to find equilibrium.

Several other studies, however, including those of Kiage (2013); Ziadat & Taimeh, (2013); Ziegler *et al.*, (2006), attributed the accelerated diminution of agricultural soil resources to the numbers of natural biophysical factors (soil properties; climatic characteristics; topography and vegetation) that control these processes in different environments. According to Prokop & Płoskonka (2014), the physical factors could sometimes interact among themselves to yield high soil erosion independent of anthropogenic impacts. In this regard, Kessler & Stroosnijder (2010), buttressed “the believed that soil erosion is caused almost entirely by the human misuse of the soil may be exaggerated” because according to him the processes of soil erosion is taking place within a biophysical environment whose role is often downplayed or ignored altogether.

This means that soil erosion can occur due to biophysical processes and events over which land managers have little or no control.

The literature presented in this section has revealed three conflicting views on the causes of soil erosion. Which are soil erosion comes about by a combination of a number of both the natural and human factors; and that it can be solely attributed to either the human factors or the natural factors. It is pertinent to opine at this point that, the dynamics of soil erosion vary from one region or locality to the other depending on the prevailing ecological and socio-economic characteristic. This study will definitely come up with the prevailing situation in the study region.

2.6.1 Biophysical dynamics and processes of soil erosion

In Nigeria, the severity of soil erosion can be attributed to intense rainfall and rugged and dissected nature of the topography in certain ecological regions. According to Kessler & Stroosnijder, (2010), soil erosion can be abstracted due to the circumstance of topography, geology, vegetation, climate, geographical location, channel characteristics, and land use which disposed of an area to soil erosion.

2.6.1.1 Climatic dynamics

In Nigeria, the major component of climate that causes soil erosion is rainfall in terms of its intensity, amount, and frequency. Soil erosion by rainfall consists of two main processes: the detachment of soil particles from the soil mass and the transportation of the detached particles. When raindrops hit exposed soil, it breaks down soil aggregates and disperses the aggregate materials to be easily removed by the raindrop splash and runoff (such as very fine sand, silt, clay and organic matter). When the intensity of rainfall is high and rapid runoff occurs, rills/gullies may develop and a large volume of water and soil may be swept away. Sheet and rill erosion are by far the most widespread form of accelerated erosion and caused agricultural production more

than other kinds of erosion. Hence, this could be the reason why Obi & Salako (1995), reported that about 70-80% of the rainfall received in Nigeria is lost as runoff; carrying an estimated 2-4 billion tones of the top soil away annually. While Ofomata (1987), have reported the annual rate of soil loss in the country as higher than the annual rate of its soil formation.

2.6.1.2 Topographical conditions

According to Hartanto *et al.*, (2003); Ziegler *et al.*, (2006), topographical conditions such as steepness, length, and shape of the slope affects soil erosion rates. In other words, the erodibility of any given landscape depends on its morphological characteristics such as the gradient, slope length and soil properties (that is, soil resistant to detach and transport). In nature, the steeper the slope of a field the greater is the amount of soil loss by water erosion (Gomi *et al.*, 2010; Wakiyama *et al.*, 2010). Erosion increases dramatically because the increased angle facilitates greater accumulation of runoff and soil movement. This means that the steeper the slope lengths the greater the erosion potential, due to increases in the velocity of water, which permits a greater degree of scouring (carrying capacity for sediment). Hence, this could be the reason why Shankarnarayan, (1995), noted that soil erosion occurs in various forms depending on land use, but the mountainous areas and sloppy fields, where agriculture is practiced are especially more prone to severe erosion hazards following excessive deforestation, faulty cultivation, overgrazing and developmental activities.

2.6.1.3 Vegetation cover / deforestation

Under natural conditions, free from the influence of human activities soil is usually covered by vegetation. Vegetation decreases the volume of runoff by increasing transpiration and evaporation (Hudson & Cheatle, 1993). It reduces soil moisture by directly increasing its capacity to absorb more rainfall and increases soil organic matter

content, which also increases soil water absorptive capacity. The removal of vegetation, whether for cropping, fuel wood, construction, mining or by grazing, accelerates erosion both by leaving the soil more exposed to rain and the wind and by changing characteristics of the soil itself, leaving it more susceptible to erosion (Hamza & Anderson, 2005). This means that soil erosion potential is increased if the soil has no or very little vegetation cover of plants and/or crop residues.

Under agricultural fields, plant and residue cover protect the soil from raindrop impact and splash (Blanco-Canqui & Lal, 2009). They, therefore, slow down the movement of surface runoff and allow excess surface water to infiltrate. The effectiveness of plants and/or residue covers depends on the type, extent and quality of the cover. According to Blanco-Canqui and Lal, (2009); de Graaff *et al.*, (2010), plants and residue combinations that completely cover the soil, and which intercept all falling raindrops at and close to the surface, are the most efficient in controlling soil erosion (e.g. forest, permanent grasses). Giller *et al.*, (2009), further stressed that partially incorporated residues and residual roots are also important as these provide channels that allow surface water to move into the soil.

2.6.1.4 Soils

Soils with faster infiltration rates, higher levels of organic matter and improved soil structure have greater resistances to erosion. Soil erosion is most severe in those areas where the soils are structurally weak and fragile particularly on hill slope areas. Most hill slope areas in Nigeria experience more serious erosion hazards because their soil types are predominantly sandy that have a weak structural stability. In this regard, Salako *et al.*, (2006b), have earlier noted that the soils in Nigeria differ in their inherent properties (that is, texture, structure, roughness, organic matter content, and soil moisture), which in turn affect their susceptibility to erosion agents or erodibility.

2.6.2 Anthropogenic factors and processes of soil erosion

The tropical region to which belongs sub-Saharan Africa has been widely recognized as the region with a much deleterious level of soil erosion compared to the non-tropical areas. Although both biophysical and anthropogenic processes contribute to soil erosion. In Nigeria, it is the anthropogenic factors that are often being adversely cited in the literature on on-farm soil erosion. A closer look at some of the assumed anthropogenic causes of soil erosion in Nigeria, through the examination of issues around yields a perspective as demonstrated below.

2.6.2.1 Inequitable land tenure

Inequitable land tenure issue is an important anthropogenic factor of on-farm soil erosion (Place, 2009). In many developing countries and Nigeria in particular, inequitable land tenure has forced many small family farmers onto steep easily eroded hillsides (Ananda & Herath, 2003). The fact that small landholders typically farm such marginal lands, therefore, may help to affect and compound this problem of soil erosion, since those farmers need immediate cash or food returns and may have problems obtaining credit for conservation investment.

Similarly, most smallholder farmers in Nigeria have no legal title defining private property rights, but have longstanding rights to the communal land (Fasoranti *et al.*, 2006; Olowolafe, 2008). A poorly defined and /or absence of property rights to most agricultural lands is a significant factor in soil erosion. For instance Olowolafe (2008) have reported the absence of an efficient set of property rights to land resources as the main cause of erosion. Empirical findings in the literature also indicated that if property rights to land are clearly specified, bargaining and trading will occur amongst the property owners and an acceptable optimal solution with the optimal level of erosion will be achieved.

Insecure land tenure and property rights weaken farmers' investment incentives in the land, especially long-term land saving investments. Lack of well-defined property rights over land was reported by Ogunwole *et al.*, (2002); Okoye *et al.*, (2008), to highly increase the rate at which farmers discount future returns to conservation activities. In effect, farmers may be less willing to invest in conservation efforts if they are uncertain of reaping the future benefits.

In contrast, several other many studies in the literature have shown that if property rights are defined for land for the control of soil erosion, it may not lead to an efficient bargaining due to large transaction costs. They augured that the number of tenant farmers and landlords is so large that the two overlap significantly. To this effect, direct negotiation among the tenant farmers and landlords to specify and monitor contracts may be too complex, and the transaction costs will be high and hence soil erosion.

2.6.2.2 Cultivation of marginal lands

Another significant factor for soil erosion under agricultural land use practices is the conversion of steep slopes and flooded plains to croplands. According to Clement *et al.*, (2013), such conversion and intensification of agricultural activities cause soil erosion, in such environment, which contains relatively poor soil and susceptible to erosion. This means that soil erosion is caused as a result of clearing and planting of marginal lands to increase the area necessary to feed the growing number of people. Hence, this could be the reason why Fuchaka *et al.*, (2002); Sharda *et al.*, (2010), reported that soil erosion is severe and the common menace to most of the world's agricultural regions but the problem is growing as more marginal lands are being brought into production. The case of the study area may not be far from these conclusions.

2.6.2.3 Inappropriate farm management practices

Soil erosion on agricultural lands also comes about with poor soil and crop management methods that are ecologically incompatible (Pimentel, 2006). This includes production on fragile soil with inadequate investment in soil conservation, limited cycling of dungs and crop residues and application of external sources of plant nutrients. In Nigeria, where subsistence production predominates, and the resource-poor farmers follow extractive farming practices and expansion of agriculture into marginal areas where the resilience ability of the soils are narrow, may not be far from this conclusion. This is because the resource-poor farmers could neither affords optimum provision of the much needed off-farm exertions necessary for the sustainable use of soil resources nor are their effectiveness assured. Such expansion of agriculture caused on-farm soil erosion, which Lal (2001), defines as the negative changes in the productive potential of the soil.

The removal of crop residues with little and/or no protection to the delicate soil against soil erosivity of the raindrop and blowing wind often cause soil erosion (Junge *et al.*, 2008). This means that the rapidly growing use of crop residues for fuel and other purposes by the rural people exposes agricultural land and intensified erosion.

Similarly, inappropriate tillage often causes soil erosion. Inappropriate tillage and cropping practices on hilly slopes, especially, according to Amuyou *et al.*, (2013); Malgwi & Abu, (2011), lowers soil organic matter levels and causes poor soil structure, that results in compaction of soils, and consequently, contributes to soil erodibility increased. This mean that compacted subsurface soil layers may increase runoff and decreased infiltration and hence erosion. Similarly, Araya & Asafu, (1999), have also reported poor tillage and cropping practices on hilly slopes to lead to the formation of a soil crust, which may also cause a decrease in soil infiltration, and subsequently, seal

the soil surface, and hence erosion. While contour plowing often practiced especially on the marginal land were found to leads to enormous soil loss and fertility decline (Blanco-Canqui & Lal, 2009).

Also, Lal (2009a), have reported that on-farm soil erosion may come about with the attendant increase in mechanical soil disturbances. For instance, plow-tillage was found to accelerate soil erosion, especially when done at a wrong time of the year (Blanco-Canqui & Lal, 2009). Although, the use of tractor provides the ease with which large land can be put under cultivation. But the implication of this as advocated by Odunze (2002), is that the tractor- hiring unit will be facing rising demand for tractor services. The consequent, therefore, could be that farmers will get their fields ploughed regardless of the slope, slope steepness, soil characteristics and cropping system as operators are always in a rush to drive over to another farm awaiting them, and hence affect soil erosion.

Several other studies, however, including those of Ananda and Herath (2003); Boardman *et al.*, (2003); Hamza & Anderson (2005), indicated that soil erosion are often caused by lack of recognition, awareness or education of land users of the causes sense of urgency, seriousness and consequences of erosion. Furthermore, Hammad & Borresen (2006) concluded that farmer's lack of systematic land resources inventory and policy for optimal land use planning, land tenure issues, and usage of conservation methods combined to yield erosion.

2.6.3 Government support policies and programmes

Empirical evidence available has shown that, in most sub-Saharan African countries, the government often establishes an agency, institutions and creates programs to improve agricultural productivity through effective soil conservation measures.

In Nigeria, the Federal government for the purpose of tackling food security problems, including soil erosion established such initiatives and programme packages. Such agency, and institutions include, National Soil Conservation Agencies (NSCA), Agricultural Development Projects (1975), National Accelerated Food Production Program (1973), Operation Feed the Nation (OFN) (1976), Land Use Decree (1978), Agricultural Credit and Guarantee Scheme (1977), Federal Ministry of Environment (FME), Federal Ministry of Agriculture (FMA), The Green Revolution Program (GRP) (1979/1980), Nigerian Agricultural Insurance Company (1984), National Agricultural Land Development Authority (1991), Directorate of Food, Roads and Rural Infrastructure (DFRRI) (1986), and the Vision 2010 Committee Inaugurated in 1996 (Aregheore, 2009).

Many of these initiatives, are not successful because they were ad hoc programs that lacked focus. Fasoranti *et al.*, (2006), reported that they were poorly conceived and implemented and were duplicates of already existing programs and organizations. In addition, the agencies and institutions were not well coordinated, the work on emergencies and give symptomatic treatment instead of identifying the causes to control erosion (Aregheore, 2009). Consequently, the results of these programs are disappointing as they enhance soil erosion.

Similarly, many researchers have presented a wealth of evidence regarding the impact of a policy environment in encouraging unsustainable use of soil resources. For instance, Murgai *et al.*, (2001), have shown that the desire of the Nigerian government to attain food self-sufficiency in the 1970s has led to the measures that provide incentives for adoption of the Green Revolution programmes. He further stated that the actively supported policies and programmes such as subsidized agricultural credit loan

and fertilizer programs have contributed to soil erosion in addition to other environmental problems.

This means that the provision of credit facilities, subsidies for erosion control, and price support for certain crops may trigger on-farm soil erosion. Hence, this could be the reason why, Obalum *et al.*, (2012), attributed the accelerated diminution of agricultural soil resources, observed in most sub-Saharan African countries partly to the connection between technical changes, economic policies the environmental dynamics.

2.7 Effects of soil erosion on farmlands

The effects of soil erosion on the soil can simply be referred to as soil degradation (Bakker *et al.*, 2007; Bindraban *et al.*, 2012). This means the lowering of the productive and other services/utility qualities of the entire landscape. Whatever, the cause of erosion, its effects can be very devastating, especially in an extreme circumstance.

For example Pimentel & Burgess (2013), have reported the global dimension of the effect of soil erosion on agricultural land to be causing an irretrievable loss of an estimated 6 million hectares each year, and crop productivity each year on about 20 million hectares to be approaching a negative net economic return. This report concurs with Hudson & Cheatle (1993), conclusion that the natural productivity of many soils has been reduced by 8-100%, because of erosion and in some areas the productivity of eroded soil cannot be restored even with the heavy application of fertilizers and other inputs. It has also been noted by FAO committee on agriculture that, an estimated 5-7 million hectares (mha) of the cultivated areas of the world are being lost every year through soil erosion. The committee further noted that if the trend of soil erosion continues about one-third of the world's arable land will be destroyed by the year 2020, and one-fifth will reduce soil productivity in the developing countries.

In the developing countries, especially Nigeria, erosion problems has culminated in significant losses of soils and consequent decrease in the nutrient capacity, moisture retention capability, organic matter content and depth of the soil which have contributed to the decline in agricultural production.

Nigeria is among the nations affected by soil erosion severity and is one of the environmentally troubled countries in Sub-Saharan Africa (Giller *et al.*, 2009; Jaiyeoba, 2003; Ndaeyo *et al.*, 2001; Obalum *et al.*, 2012; Olowolafe, 2008; Ray & Yusuf, 2011). Soil erosion by water constitutes a severe threat to the valuable soil resources and the associated agricultural productivity as well as reduction of arable lands and siltation of the various water bodies across the country. Resulting in reduced grazing lands, low yields, famine, decrease in the availability of fuel wood, low standard of living, migration of rural dwellers, food insecurity and poverty.

According to Adediji *et al.*, (2010), the human induce soil erosion has affected approximately 53.028 Km², (80%) of cultivable lands in northern Nigeria, from proportion, about 40% is rendered totally useless for cultivation. In southern Nigeria, about 53.028 Km², (80%) of the cultivated fields has been impacted, out of which more than 22% is put out of production. He further concluded that, in Nigeria as a whole, more than 50% (40 million hectares) of the cultivated land is under medium to long-term fallow as a result of the ravages of erosion. Similarly, Adebayo & Tukur, (2003); Blanco-Canqui & , (2009); Jaiyeoba, (2003), has discussed that every year some 20 to 30 thousand hectares of cropland in the northern part of the country is brought out of production due to soil erosion and the consequent soil degradation.

In the same vein, the rapid rate/severity of soil erosion in Nigeria as observed by Thapa & Yila, (2012), has cumulated into a significant loss of soil productivity and consequent decrease in the farmers' income and the national economic of the country

that is basically agrarian. To this end, Abayomi (2012); Igbozurike *et al.*, (1989), reported that the country food production is reduced by 1-5 percent annually, as a result of the ravages of erosion. Adediji (2000) estimated that the average annual loss of crop productive capacity through erosion to be about 25 millions tones per year.

Similar, Junge *et al.*, (2008), have estimated soil erosion to cost Nigeria on average 2.5 percent of soil productivity annually from that of the 2000 productivity level. In addition, FAO, (2013); Okoye (2009); Salako *et al.*, (2006), also estimated that erosion has cost Nigeria 5-17% of its Gross Domestic Product (GDP) between 2000-2010, and projected an increased GDP loss of about 23 to 49% by 2025. This shows that the trend of the impact of soil erosion by water is increasing from time to time rapidly in the country. Moreover, the economic cost of soil erosion in Nigeria is estimated to be around USD 1.5 billion per year (Bojö, 1996; FAO, 2013). In addition, Junge *et al.*, (2008) also estimated that the minimum annual cost of soil erosion on the Nigerian national agricultural GDP ranged between 2 and 4 percent. This also clearly shows the extent of the effects of soil erosion on the country's structural food insecurity problem.

However, NEST (1996), has noted that the eroded soil, when deposited somewhere else, can constitute a big nuisance. For one, it submerges fertile arable land or crops as well as causing blockages in irrigation channels. Thus making access to agricultural field difficult, these deposited materials could also close up drainage-situation that may result in flooding.

2.8 Farmers' perception of soil erosion

Perception, according to Lewin (1951), one of the foremost authors in the behavioral studies, is a behavioral product of individual life space or what he also calls the psychological environment. To, Cox (1972), perception is a "pieces of knowledge, which are acquired by the individual as a result of his visual, tactile, verbal and auditory

contacts with the environment about him”. It is the stimulus/response aspect of the process of decision-making with the locational implication (i.e. spatial and environmental pattern); this is how Burton (1972), defined perception. To, Duruiheoma *et al.*, (2015), it is the social role of attitudes, which provide an input into the planning process and serve as a vehicle for public participation in decision-making. While Ray *et al.*, (1999), simply gave an explanation of perception as “the impression one has of a social stimulus or set of stimuli. Such impression according to him is modified by the perceivers’ past experience in general; demographic, socio-economic, institutional and physical factors. There are two types of perceptions; designative perception and appraisal perception (Cox, 1972). Designative perception, is a perception that an individual have of the attributes of a place and which are devoid of all evaluations of those attributes and appraisal perception, are the perception of those value judgment that an individual have of a place.

The above definitions of perception simply imply that perception is a piece of knowledge, which is governed by individuals’ past experience in general. It may not necessarily be accurate by scientific standards; rather it may be more or less accurate, and differences in perception can occur among people living in the same location and sharing the same resources. Thus, since individual perception is governed by past experiences, the soil erosion perceptions of the individuals’ farmers are to be understood if proper intervention measures of soil erosion are to be advanced and long time management strategies successfully adopted. As suggested by Bewket & Sterk, (2002); Fairhead & Scoones, (2005), the views of different actors in soil conservation should be considered, because they all have their own perceptions on soil erosion and the criteria used for it. This view is conformity with the explanation earlier provided by the soil, learning perspective, where, they held that different actors perceive different things according to their engagement with the immediate environment. Thus, land users

have their own reasons for what they do with their land, their perception of the process and whether they see any problem or not.

There are two different schools of thought about farmers' perception of soil erosion. One school believes that farmers misperceive either the existence or the extent of erosion on their individual farm due to the insidious nature of the pervasive hazard of soil erosion (Yusuf & Ray 2011). Miscalculation of erosion may range from denying its existence to dismissing reports of erosion and its effects. Supporters of this argument held that soil erosion is a very slow process and almost invisible, therefore, land managers, may ignore and/or exacerbate it by its insidious nature (Moges *et al.*, 2013; Okoba & de Graaff, 2005).

For instance, on the level of individual perception as noted by Okoba & de Graaff (2005), erosion is often ignored and exacerbated by its insidious nature. He further shows that, although farmers are aware of the added effort and cost of controlling soil erosion, the damage caused by erosion often goes unnoticed. It has also been stated that even if farmers do accurately perceive soil erosion as a problem they may not be induced to act to reverse it. They may attribute the problem to natural or divine causes beyond their control (Assefa & Hans-Rudolf, 2016).

The second school indicated that farmers perceptions of the effects of erosion on crop yield and erosion as major individual problems for them are associated with the use of soil conservation measures (Amsalu & de Graaff, 2006; Bewket & Sterk, 2002; Knowler & Bradshaw, 2007; Okoba & Sterk, 2006). They further noted that over a long term farmers experience with the pervasive hazards of soil erosion can lead to a psychological adjustment to the condition and to under estimating its seriousness for them on their own farm. They further noted that an interested person like a farmer might

notice a lighter soil colour, unproductive spots, and nearness of rock to the soil surface than before.

The literature presented in this section has revealed two conflicting views on farmers' perception of soil erosion. Which are farmers misperceive either the existence or the extent of soil erosion on their individual farm and that over long term farmers experienced with the pervasive hazard of soil erosion can lead to a psychological adjustment to the conditions to underestimating its seriousness for them on their farms. It is pertinent to opine at this point that, farmers' perceptions vary from one region or locality to the other depending on the prevailing ecological and socio-economic characteristic. This study will definitely come up with the prevailing situation in the study area.

2.8.1 The importance of farmers' perception in soil erosion studies

The importance of understanding soil erosion phenomena from farmers' perception cannot be over emphasized. As stated by Bewket (2011); Dalton *et al.*, (2011); Odendo *et al.*, (2010), it is an important mechanism for the formulation of erosion control policies. The main prerequisite for attaining sustainable soil conservation measures is the formulation of appropriate soil conservation policies, which are supported by the farming communities (Barnes *et al.*, 2013; Gruver & Weil, 2007). The responses, commitments and responsibilities required for the success of such policies depend on the knowledge and perception of the problem by peasant farmers.

In the state of nature, to identify changes that occur, it is valuable to gain an understanding of the awareness of the physical processes and the changes of soil management systems. Therefore, understanding soil erosion and conservation measures from the farmers' perception remains of paramount important because farmers are often more acutely aware of the condition of their land than is sometimes does by an expert,

who is an occasional visitor. Ndiaye & Sofranko (1994), states that the peasant farmers have a detailed understanding of the biophysical characteristics of their land than is sometimes does by an expert, who is an occasional visitor. Furthermore, he stresses that the soil erosion problem is real issue and the problems that the peasant farmers experienced in their farming systems.

A similar study by Knowler & Bradshaw (2007); Odendo *et al.*, (2010), indicated that such studies provide a guide to researchers and agricultural extension personnel in refining their research and conservation agenda to respond to the needs felt by farmers. In addition, a recent analysis of the literature across other parts of Nigeria, and the study region, in particular, revealed scanty and skewed research efforts. While, farmers' perception of soil erosion varies from place to place and from household to household depending on the prevailing ecological, economic, and sociocultural characteristics. Therefore, the results from elsewhere cannot extrapolate to the northern part of Taraba State.

2.8.2 The indices of measuring farmers' perception of soil erosion

Perception is “a process of information extraction by which people select, organized and interpret sensory stimulation into a meaningful and coherent picture of the world”(Ndiaye & Sofranko, 1994). Perception by man as noted Arslan & Taylor (2008); Moges & Holden (2007), is greatly influenced by the ways he sees the soil through information he receives about the soil. However, they further noted that man/ soil relationship is greatly affected by some factors that determine perception, such factors include the educational level of informant, level of exposure, age, sex, cultural background, interest and needs, beliefs, attitude and experiences of the individual perceiving it as well as the level and duration of involvement with modern technology.

However, farmers' perception of soil based constraints, and their broader production objectives and ideas concerning production potential and limitation, together with other

environmental, cultural and economic considerations, are all used in “making decision or responses” on a particular farming practice; to mitigate the effects of soil erosion (Woomer *et al.*, 1994). See figure 2.2. This means that Farmers’ decision to conserve natural resources generally and soil, particularly are largely determined by their knowledge of soil erosion problems and perceived benefits of conservation. These decisions do not only influence the outcome of the farm activity, but also have feedback effects on the soil resources and the farmers’ social, cultural and economic circumstance.

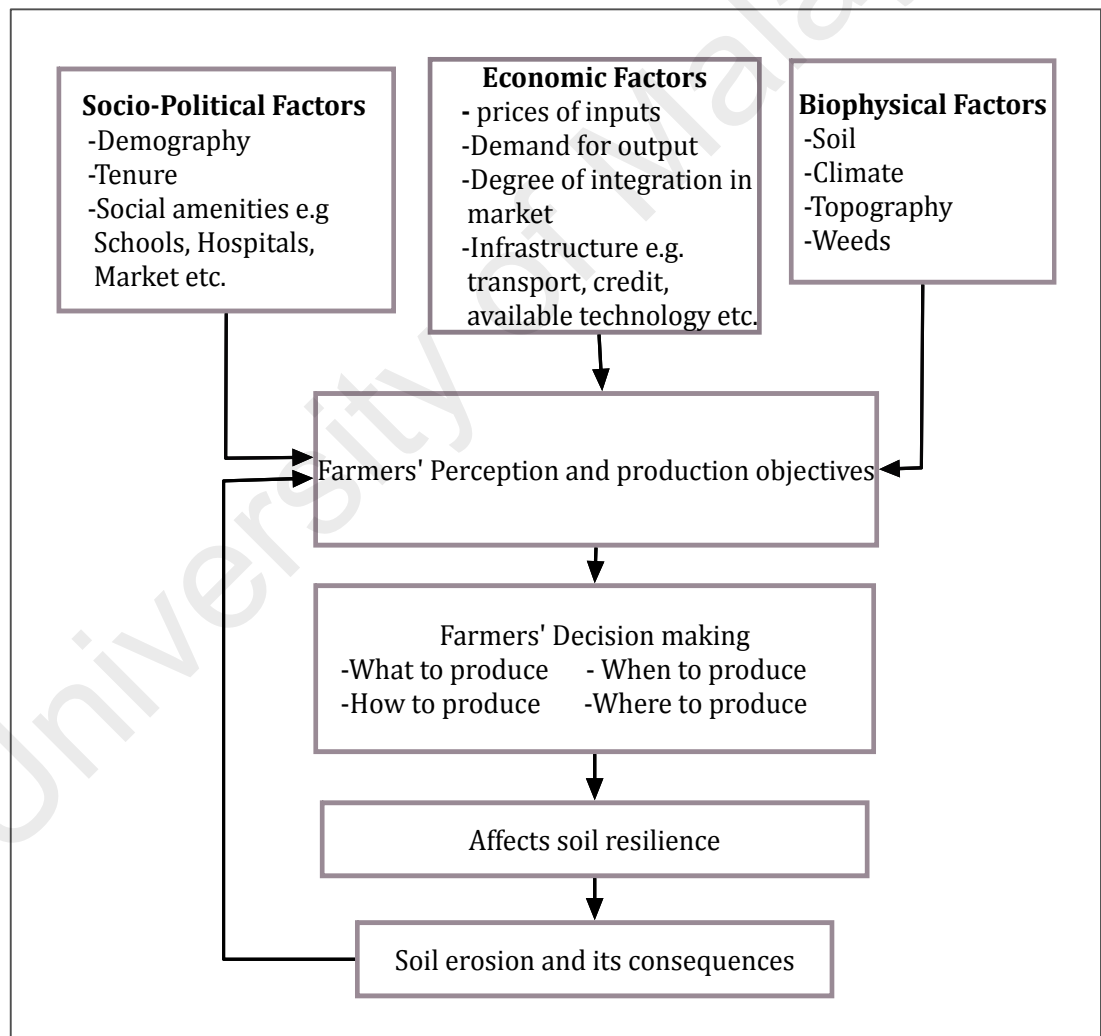


Figure 2.2: Factors affecting farmers’ Perception of soil erosion

From figure 2.2, it can be seen that decision or responses do not only influence the outcome of the farm activity but also have feedback effects on the environment. The environment includes soil among others, such as atmosphere, and hydrosphere. Farmer's responses are based on a judgment between options that relate to this whole range of economic, cultural, and biological parameters. Nonetheless, as noted by De Graaff *et al.*, (2008); Preston *et al.*, (2000), there are two fundamental components that have the greatest influence on farmers' decision or responses, which are the farmer's production objectives, and his/her perception of the consequences of the various causes of action. Warren *et al.*, (2003), further explained that, though production objectives vary with farmer's circumstance, personality, and past life history, but in general, however, these objectives are likely to be dominated by desire to increase net revenues for the household and to reduce the risk of crop failure by promoting soil productivity/yield stability.

2.9 Socio-economic status and farmers' perception of soil erosion

The interactions between the social-political (farmers' education, age, sex, household size, land tenure, labour availability, credit facilities, extension services, political stability, etc.), and economy (income level, price of inputs, demand for output, capital) variables determine the emergence of soil erosion incidence (Figure.2.3) (Boardman *et al.*, 2003; Long *et al.*, 2007). This means that linkages between the social and economic variables remain of paramount importance in soil erosion studies.

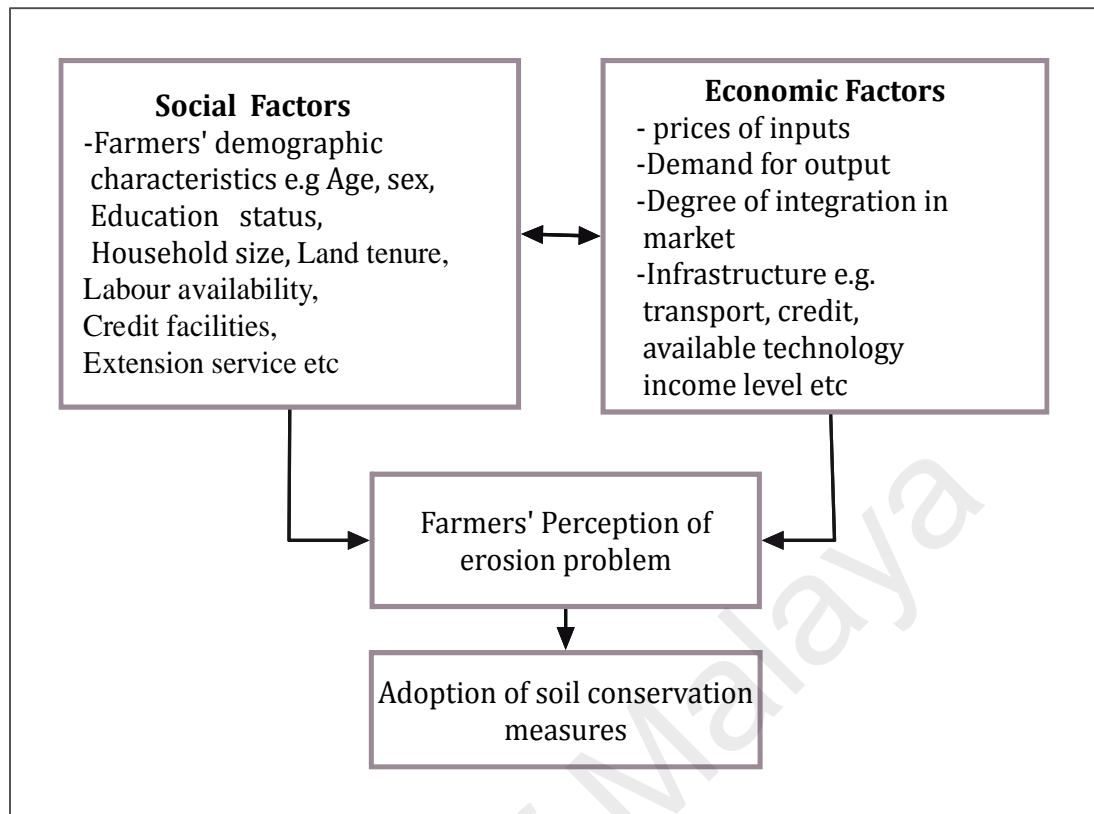


Figure 2.3: The relationship between socio-economic factors with soil erosion

2.9.1 Social factors affecting farmers' perception of soil erosion

2.9.1.1 Education

Social factors influence soil erosion in that it affects the behaviours of farmers towards erosion control measures. For example, Huffman (2001), observed that, both theoretically and empirically, farmers, with higher education possess high allocative ability and adjust faster to the understanding of soil erosion in their farms. He further noted that education is particularly important when extension activities are less intense. The above study was inspired by the work of Green and Heffernan (1987), who had earlier showed the importance of human factors in dealing with the situation of soil erosion and nutrient imbalance.

Education plays a vital role in determining the rate of controlling erosion. For example, a study by Recha *et al.*, (2014), Nyeko *et al.*, (2007), in Uganda, have

indicated that exposure to education enhances the awareness of farmers on new technology and hence increase the capacity of the farmers to accept and apply a given technology. Sattler & Nagel (2010); Tenge *et al.*, (2004); Udayakumara *et al.*, (2010); Wauters *et al.*, (2010); Wolka *et al.*, (2013), discussed that education enhances farmers' willingness to adopt new techniques and improve their management capacity. Other cases studies in Nigeria including those of Akinagbe & Umukoro, (2011); Matata, *et al.*, (2010), indicated that education had a significant influence on farmers' choice to adopt soil conservation measures. Similar findings have been reported by Ervin & Ervin (1982), in their analyses of cross-sectional data based on a survey of Missouri farmers, where the likelihood of undertaking conservation measures was significantly correlated with the farmers' education as well as the degree to which they perceive erosion to be a major risk. Also, education was found as significantly related to conservation efforts (Babatunde *et al.*, 2007).

2.9.1.2 Age

The age of a farmer is a significant social factor that influences soil erosion, in that it affects the adoption of soil conservation for erosion control and fertility depletion (Omeregbee *et al.*, 2013). The relationship between age and adoption of soil conservation measures has been seen from different point of views. For example, a study by Okoye *et al.*, (2008); Vu *et al.*, (2014), showed that the age of the farmers tends to influence soil conservation decision negatively, in that it decreases their participation on erosion control. Similarly, an indifferent relationship between the ages of farmers and their adoption of soil conservation measures has been reported by Bewket (2011), in Ethiopia, while, a positive relation between age and adoption of soil conservation measures were acknowledged by Sidibé (2005), in the case of Burkina Faso, and Fosu-Mensah *et al.*, (2012), in Ghana. However other studies carried out by

Amsalu & de Graaff, (2006); Anley *et al.*, (2007); Assefa & Hans-Rudolf, (2016), found no relationship between age and adoption of soil conservation measures.

2.9.1.3 Sex

Sex is another social variable, which affects farmers' responses regarding soil erosion. For example, in Ethiopia, Bekele & Drake (2003); Gebremedhin & Swinton (2003), have reported that sex of farmers is the critical factors influencing the efficacy of the farmers' decision to adopt soil conservation measures. In Nigeria, Ogunlela & Mukhtar (2009); Thapa & Yila (2012), reported a positive correlation between the farmer's sex and the number of soil conservation technologies adopted. Similarly, Basu *et al.*, (1986); Tesfaye *et al.*, (2014), have reported a positive effect of farmer's sex, on the adoption of soil conservation practices for the control water erosion and fertility depletion.

2.9.1.4 Household size

Household size is another social variable, which affects farmers' responses regarding soil erosion. This is because; as observed by Mazvimavi & Twomlow (2009), large household's size is a proxy for labour availability and soil conservation practices generally required more labour inputs, while, labour shortages may limit the extent of adoption of erosion measures. This corroborated some findings that the family size is one of the most important factors controlling the level of production and productivity of small-scale farmers (Qasim *et al.*, 2011; Tenge *et al.*, 2004). This means that large household's size is a proxy for labour availability, and may influence the adoption of soil conservation positively as its availability will reduce the labour constraints.

However, several other investigations in literature, including those of Jayne *et al.*, (2003); Kabubo-Mariara *et al.*, (2006); Long *et al.*, (2007), have shown that, the ability of the large family size to provide the needed labour requirement for farming, in many

developing countries, including Nigeria, have been obstructed by the limited and small farm hectares cultivated. Similarly, Sattler & Nagel (2010); Udayakumara *et al.*, (2010), have indicated that households with many family members may be forced to divert part of the labour force to off-farm activities in an attempt to earn income to ease the consumption pressure imposed by a large family size.

2.9.1.5 Landownership

According to Brasselle *et al.*, (2002); Deininger & Jin (2006); Fenske (2011), secured landholding provides farmers with incentives including transferring land possession to their children and as collateral. It also encourages farmers to effectively plan and implement relatively permanent soil conservation structures on their farm plots. This means that insecure landholdings invariably decrease farmers motivation to apply soil conservation measures, mainly due to lack of assurance that they may reap the benefit at the end of the conservation process.

A number of empirical and descriptive studies on the effects of land ownership and the proportion of farms rented on the adoption of soil conservation to control soil erosion and fertility depletion have been widely investigated. For example, studies by Fenske (2011); Hartvigsen (2014), have revealed that, tenants have a lower tendency to adopt soil conservation practices, compared to owners because of attitudes and fear that since they are just using it (the farm) for a short period of time and may not gain access to such farms again. Similarly, Ajayi *et al.*, (2007); Erenstein (2002), noted that tenants are unwilling to apply fertilizer and input on the farm because they are not sure of gaining access to the land again, couple with the fact that at times fertilizers used may only be effective in the next cropping season.

In contrast, Abdulai *et al.*, (2011); Deininger & Jin (2006), has equally noted that tenants were not only as innovative as landowners but sometimes used more fertilizers

per hectare than did land owners for soil conservation. He further explains that at times landowners may not allow the plantation of perennial crops because the tenant may claim ownership based on the evidence of the planted trees, despite the fact that such trees are essential for erosion control.

2.9.1.6 Farm sizes

Land use and the practice of soil erosion and fertility depletion measures have a strong positive or negative relationship with farmer's farm sizes. For example, a study by Moges *et al.*, (2013); Saint-Macary *et al.*, (2010), have reported a positive association between farm size and practice of soil erosion and fertility depletion measures. This means that farmers with larger holdings are more likely to adopt lumpy technologies for erosion control and soil fertility enhancement than those with smaller holdings because adoption costs relative to farm size are lower. An unenthusiastic relationship between farm size and the practice of soil conservation measures was reported by Odoemenem & Obinne (2010); Yila & Thapa (2008), in Nigeria. However other studies carried out by Adesina & Chianu (2002); Tiwari *et al.*, (2008), found no relationship between farm size and the adoption of soil conservation measures.

In Nigeria, particularly in the northern part of the country to which belong the research region a study by Essiet (1990); Ogunwole *et al.*, (2002); Onyewotu *et al.*, (2003), reported that farm holdings are generally small (mean hectares being less than 1), based on Shaib *et al.*, (1997), farm holdings classifications. Where, small-scale holdings were classified to range between = 0.10 to 5.99ha; medium scale holdings between 6 to 9.99ha, and large-scale cultivation from 10ha and above. This small farm size indicates that the farmers were basically peasant farmers operating on small farm size.

In contrast, several other investigations, including those of Okoye *et al.*, (2008); Ugwuja *et al.*, (2011), in the southern Nigeria, reported that the mean hectares of cultivated fields per farmer were about 2.5 ha. This implies that farmers from the southern part of Nigeria cultivate relatively larger hectares of land than their counterparts in the northern region of Nigeria.

2.9.1.7 Farm distance

The distance of farm plot from homestead has a role on farmer's decision to adopt soil conservation practices. A study by Girei & Giroh (2012), found a significant and negative correlation between soil conservation decision and distance of a parcel from the residence, but positive correlation between homestead farms and adopting conservation decision. Farmers residing close to their cultivated land invest more on soil conservation measures than their counterparts living at a distance. Thus, farmers invest more in soil and water conservation in fields situated near to residences. Farmers' farm distance can also have an influence on the decision to practice soil conservation measures, especially, mechanical one.

2.9.1.8 Farming experience

In the African traditional context, farming experiences refer to a tool for acquiring and developing farmers' understanding of indigenous knowledge system, and its uses in soil erosion and conservation practices (Ainembabazi & Mugisha, 2014). This means that farmers with long years of farming experiences would be more conversant with soil erosion problems and its constraints to adoption of soil conservation measures.

For example, a study by Genene & Wagayehu (2010); Ndiaye & Sofranko (1994); Rushemuka *et al.*, (2014), have indicated that long period of farming experiences increases the probability of uptake of all soil conservation technologies. They further buttressed that; experienced farmers may have better knowledge and information on

crop and soil management practices, than inexperienced farmers. This concurred with the findings earlier reported by Green & Heffernan (1987); Kiome & Stocking (1995); Willock *et al.*, (1999), that, long period of farming experiences increases farmers level of acceptance of new ideas as a means of overcoming their production constraints and hence, the practice of both soil erosion and fertility depletion measures to increase production.

Moreover, farmers' perception of soil erosion is governed by past experiences. Therefore, if standard measures of soil erosion and conservation practices are to enhance and properly implemented, the individuals' farming experiences needs to be understood, especially in the African traditional system

2.9.2 The economic factors affecting farmers' perception of soil erosion

The economic factors contribute in controlling soil erosion, through its influence on decision-making. For instance, a study conducted by Barungi, *et al.*, (2013), have shown that high agricultural economic efficiency increased households' enthusiasm for agricultural investment. Similarly, Knowler & Bradshaw (2007) indicated that farmers' ability to understand and bear soil erosion and conservation risk are influenced by his economic factors. Similarly, having off-farm income was found to influence the farmer's enthusiasm and ability to use effective soil conservation options (Babatunde & Qaim, 2010; Bekele & Drake, 2003). To, Babatunde (2008), households with higher income have a better understand of soil erosion processes and adopt effective soil conservation practices in their fields than farmers with low income. This means that under relatively high level, high demand for outputs, besides the personal perception and knowledge of the individual farmers, farmers tend to increase their efforts in soil erosion control. This analysis relates to the present study because, the idea underplaying

it could be used to explain the socio-economic constraints on soil erosion control in the study region.

In addition, recent analysis of the literature across other parts of Nigeria and most Sub-Saharan African countries such as those of Anjichi *et al.*, (2007); Ibrahim *et al.*, (2009); Nwaru *et al.*, (2011); Oluwasola & Alimi (2008), have shown that off-farm income also influenced farmer's enthusiasm and aptitude toward improving the level of soil conservation effort. According to Nkamleu & Manyong (2005); Nwaru *et al.*, (2011), the economic factors contribute to soil erosion control since crop production is the immediate concern to many farmers.

The adoption of measures for the control of soil erosion depends heavily on the assumed benefits and risks attached (De Graaff *et al.*, 2008; Moges & Holden, 2007; Vignola *et al.*, 2010; Warren *et al.*, 2003). This implies that a farmer is less likely to implement soil conservation measures, which do not result in positive changes for crop production, as these measures require a significant investment.

In contrast, several other studies in literature, including those of Adimassu *et al.*, (2013); Bewket (2011); D'Emden *et al.*, (2008), has shown that despite the general assumption that farmers' decision are mostly driven by economic rationality, cost was not found to be the most important factor, but other factors like associated risks, effectiveness, or time and effort necessary to implement a certain measure were equally or even more important in influencing farmers' decision for soil erosion control. This analysis relates to the present study because, the idea underplaying it could be used to explain the socio-economic constraints on soil erosion control in the study Area.

2.9.3 Biophysical characteristics affecting farmers' perception of soil erosion

Besides to the farmers' socioeconomic characteristics, farmers' perception could also influence by biophysical characteristics such as slope, soil colour, and moisture holding capacity.

Slopes of the cultivation fields either motivates or de-motivates farmers towards the decision to practice soil conservation. Hence, farmers located in steeper slopes tend to control soil erosion through the use of appropriate measures, whereas the counterparts' delay in the application of soil conservation methods owing to situate on a flat slope. The study by Kimaro *et al.*, (2008); Ziegler *et al.*, (2006) stated that farmers' cultivating steep slope fields install more effective conservation measures than farmers that cultivate level fields. They detailed that soil degradation is better perceived among farmers of the highly degraded areas than their counterparts in less degraded areas. On the contrary, farmers in the erosion less prone areas (level fields) do not employ conservation measures on their farmlands. Another study by Yila &Thapa (2008) reported a positive association between existences of recommended types of conservation structures and concluded that slope affects farmers' decision to adopt conservation structures positively. Also, Wauters *et al.*, (2010), observed frequent conservation practices installed on steeply sloping cultivation fields which reflect the desire of farmers to control soil loss from highly erodible soil.

2.10 Soil conservation measures

Soil erosion by water is a common environmental problem that affects the sustainable development of agriculture, especially of the developing countries (Anley *et al.*, 2007; Bewket, 2007). Several countries, or communities threatened by this phenomenon, adopt different measures to preserve and protect their soil resources (de Graaff *et al.*, 2010; Haregeweyn *et al.*, 2015). Restoring soil quality is vital to human

survival. Several civilizations that chose not to pay attention to this dictum vanished because they took soils for granted (Doran & Parkin, 1994). Political stability and peace are threatened especially in Sub-Saharan Africa and Nigeria inclusive because of soil erosion, and desperateness caused by the ever-dwindling soil resources (Junge *et al.*, 2008; Tenge *et al.*, 2004; Tesfaye *et al.*, 2014).

Soil conservation measures refer to efforts made by farmers to control water erosion and depletion of soil fertility (Briggs, 2005; Daniel *et al.*, 2007; Gebremedhin & Swinton, 2003). Fundamentally, what soil conservation tries to do is to introduce and promote stable system of land use and management, which control erosion and prevent on-farm soil fertility depletion in three different, but related ways, Firstly by protecting the surface of the soil as far as possible from the effects of raindrops directly striking the soil surface, secondly by trying to ensure that maximum amount of water reaching the soil surface is absorbed by the soil, and thirdly, by attempting to make any water which cannot be absorbed, drain off at velocity which is low enough to be none erosive. This is translated into adopting biological and physical techniques in conserving and protecting the soil from degradation (Adimassu *et al.*, 2014; Amsalu & Graaff, 2006).

Therefore, as stated by Dimelu *et al.*, (2013); Kiome & Stocking (1995), soil management challenges for developing countries especially the sub-Saharan countries and Nigeria, in particular, should include achieving food security with minimal risks to soil resources. This is imperative given the Nigerian per-capital arable land area decreasing to <0.1ha, and per capital irrigated land area to <0.04 ha, while, the rate of its productivity growth has declined from 2% yr⁻¹ during the Green Revolution to 1% yr⁻¹ today. Moreover, its population growth remained among the highest in the world.

Thus, appropriate soil management practices to raise agricultural productivity on existing lands are needed to feed the ever-increasing local population in Nigeria, and the

over 9 billion people of the world by 2025 (Cobo *et al.*, 2009; Erenstein, 2002). To this effect, halting soil erosion to avoid losing even more valuable farmlands or raising soil fertility on existing farmland to boost yield and address other challenges on and off farms that have contributed to low agricultural productivity is essential to any programme to boost agricultural productivity in sub-Saharan countries and Nigeria in particular, where subsistence agricultural production predominates, and who's farmers on the average cultivate one hectare of food crops and keep some livestock due land tenure issues.

2.11 Factors that determine the adoption of soil conservation

A decision on the adoption and types of soil conservation measures to use and where to place them were made by the farmer's concern (Tesfaye *et al.*, 2014). Farmers' decision to conserve natural resources generally and soil particularly is largely determined by their knowledge of the problems and perceived benefits of conservation (Odendo *et al.*, 2010; Okoba & De Graaff, 2005). Therefore, farmers' perception of soil erosion is an important precondition for the adoption of conservation practices.

A lack of appreciation of farmers' knowledge and their perceptions of soil erosion and soil conservation measures was found to be the reason for the low adoption of recommended technologies (Daniel *et al.*, 2007; Tiwari *et al.*, 2008). In their investigation, Adebayo & Tukur (2003); Adimassu *et al.*, (2013), found that the majority of the farmers believed that erosion could be halted and they perceived soil conservation measures as an effective option for successful increase in soil productivity, soil water retention, and increase land value. Similarly, Cobo *et al.*, (2009); Daniel *et al.*, (2007); Moges & Holden (2007), reported that, farmers' awareness and their exposure level to soil erosion combined with their perception of risk, and personal beliefs along with territorial exposure were the main determinants of the farmers' level

of adoption of soil conservation. Similarly, Abdulai *et al.*, (2011); Gebremedhin & Swinton (2003), also indicated that the wealth status of farmers, land tenure arrangements and lack of access the farmers have to information are the major factors affecting soil conservation. Bewket (2007); Fairhead & Scoones (2005); Odendo *et al.*, (2010), have reported the knowledge of soil erosion processes, attitude towards the rational use of resources and institutional support as the major factors affecting the capacity of farmers to implement soil conservation measures. In addition, high labour demands, lack of tools, lack of short-term benefits and free grazing were reported to have a negative effect soil conservation adoption (D'Emden *et al.*, 2008; Dalton *et al.*, 2014).

2.12 Farmers' types of soil conservation practices

Most traditional farm methods in Africa and Nigeria, in particular, have some kind of conservation methods (Assefa & Hans-Rudolf, 2016; Kagabo *et al.*, 2013). These traditional farm conservation methods are carried out by individual farmers both on a small and large-scale basis depending on the size of the landholding. They are relatively labour intensive requiring expertise skills (full knowledge of the operations) and relatively small capital.

The soil conservation practices can be broadly categorized into three areas according to the types of soil degradation: 1. Water erosion measures, this includes measures such as grass strips, soil/stone bunds, and contour vegetation barriers that control both run-off and run-on and harvest rainwater (Adimassu *et al.*, 2014; Briggs, 2005; Cobo *et al.*, 2009). 2. Soil fertility control measures, which refer to measures such as the application of organic amendments or inorganic fertilizers that replenish or improve the fertility of the soil. 3. Finally, mixed control measures, encompassing practices such as alley farming and other Agroforestry systems, that aim at retaining soil nutrients and

preventing water erosion through the integration of trees, shrubs, and crops (Amsalu & Graaff, 2006; Anley *et al.*, 2007; Chen *et al.*, 2007).

2.12.1 Mechanical soil conservation measures for safe disposal of run-off are:

Mechanical methods are on-farm activities or practices that help to halt the force of wind or lessen runoff velocity to halt soil erosion; such as tied ridges, construction of soil/stone bunds along contours; waterways and structures such as vegetative barriers (Junge *et al.*, 2009; Nyssen *et al.*, 2009; Vancampenhout *et al.*, 2006). Even though, the mechanical soil practices are effective soil conservation options, which decrease soil loss, their construction and maintenance are normally labor- intensive. Hence, farmers might less likely adopt these structures.

2.12.1.1 Terraces

Is a form of soil conservation techniques, mostly installed along the slope of cultivated fields to prevent erosion (Amsalu & Graaff, 2006; Hammad & Borresen, 2006; Kagabo *et al.*, 2013). It is usually built, by arranging stones very high (as high as 2 feet), depending on the prevalence of the stones. The stones were normally continually removed in between the ridges to leave the soil for cultivation. A well-made contour farm will prevent soil erosion and conserve both soil and water, as it allows it to sink rather than run-off.

For instance, field trial on terraces carried out by Olowolafe (2008), in Jos plateau, northern Nigeria, revealed an increased in the average soil losses from an untreated plot with terrace 2.3 t/ha⁻¹ and a decrease from a terraced plot, 0.7 t/ha⁻¹. However, despite, its positive effect in conserving both soil and water, the job is very tedious and requires large amounts of construction materials, time, and patience that the Womenfolk and elderly people are better placed to provide. In Nigeria, terraces are mostly built in

Mokwa and the pankshin area on the Jos Plateau and part of Adamawa and Taraba states (Chianu & Tsujii, 2004; Hoffmann *et al.*, 2001).

2.12.1.2 Ridges and Mounding

Farmers also perfect the used of ridges and mounding, which involve the making of rectangular spaced embankment with a plough. A mounding body or a hand tilling instrument is used, where the earth is taken from the space between two crops rows to an untilled part and plants are usually seeded on top in most cases or even on the side of the ridges that need to be banked up during the cropping cycle (Cobo *et al.*, 2009; de Graaff *et al.*, 2010). The principles behind this technology are to trap rainwater, prevent surface runoff and overland flow and make more water available for plants. However, the goals behind perfecting it are achievable only if the ridges are constructed perpendicular to the direction of the slope and the slope is gentle or low.

2.12.1.3 Structures

Another form of mechanical on-farm soil erosion control measure is building of structures barrier. The structures are often built of stones and vegetation installed along contour lines to served as filters. Such structures do not only decrease the runoff amount, but also impede its velocity, and consequently, encouraging sedimentations, increasing infiltration, and facilitating the formation of natural terraces (Wolka *et al.*, 2013; Yila & Thapa, 2008). Vegetative barriers are typically built in the form of strips of several meters wide and mostly with *vetiver* (*vetiver zizanioides*) grasses. *Vetiver* is perennial grasses, which have a deep, and fibrous root systems found mostly in the northern part of Nigeria and can withstand denudation, fire, drought, and flood. Hurni (1988) had discussed the types of grass species that could be used for establishing vegetative hedges in the humid tropics and revealed that the thick root systems of the *vetiver* checked riling, gullyng, and tunneling.

2.12.2 Soil conservation practices for maintaining infiltrations (Mulching)

Mulch is a layer of dissimilar material placed between the surface and the atmosphere. Different types of materials such as residues from the previous crop, brought in mulch including grass, perennial shrubs, farmyard manure, compost, byproducts of agro-bases industries, or inorganic materials and synthetics products can be used for mulching (Erenstein, 2002; Odunze, 2002). However, for mulch tillage to be effective, the mulch materials, must be applied in sufficient quantity to cover as much as 70% to 75% of the soil surface. Empirical evidence has shown that the mulch rate of 4 to 6 t ha⁻¹ is required for an optimal water erosion control. For instance, in an experimental study conducted by Odunze (2002), on soils of northern Nigeria, an increase in maize grain yield of 40% was recorded when, 2t ha⁻¹ of mulch was added, and an increase in maize grain yield of 80% when 4 t ha⁻¹ of mulch was added on the soils. He recommended that 2-to 4 t ha⁻¹ of straw mulch should be added for an optimal increase in yields.

In general, the principles behind this tillage technique are to: protect the soil by limiting runoff and consequently erosion, reduces the effect of evaporation, facilities infiltration, enrich the soil with organic matter and increase *mesofauna* (earthworm) activities and minimize surface soil crusting by reducing the impact of raindrop (Ogunwole *et al.*, 2002).

For example, an experimental study conducted by Salako, *et al.*, (2006), on previously eroded tropical alfisol soils with herbaceous legumes, to compare the influence of burned residues with mulched residues from *mucuna pruriens* and *puraria phaseoloides*, revealed that the soil loss from plots with burned residues of *mucuna pruriens* were significantly higher (6 and 2.8 tha⁻¹) compared to plots treated with mulched residues (1.5 and 1.3 tha⁻¹ of *puraria phaseoloides*) This finding is consistent

with the results of several case studies reported across different regions of Nigeria. For instance, the bulk density and penetration resistances of soil were found to decrease by mulching (Odunze, 2002). The infiltration capacity and hydraulic conductivity of soils were found to be five times much higher and its transmissivity about four times much more higher in plots treated with mulch, compared untreated mulch plot. Sidibé (2005), further suggested that incorporating residues might be more beneficial than applying them on the topsoil as the surface roughness is increased and the soil structure more open with depth.

Similarly, soil temperature was found to reduce by some degrees in the upper centimeters of the topsoil where crop residues are applied. Thus, crop residues provides better moisture conservation mechanism through its ability to reduce the intensity of radiation, evaporation, and wind velocity, as well as an increase in the organic carbon and nutrient contents of the soils (Powlson *et al.*, 2011; Thierfelder *et al.*, 2013). The complete or partial crop residues removal from the cultivated farm for other uses including firewood, animal fodder, and construction materials are the major impediments that makes the practice soil conservation measures using mulching less pertinent (Haregeweyn *et al.*, 2015; Kagabo *et al.*, 2013).

However, the major limitation of mulching technology is that, it requires long periods of time for the optimal changes in the soil properties to occur, hence, less attractive to the farmers in that the soil conservation options, which farmers especially, those in the developing countries have the highest likelihood of being adopting are those which result in sufficiently significant short-term increase in yields (Chen *et al.*, 2007; Grimaldi *et al.*, 2013). This is more so because they subsistence-oriented small-scale farmers are always uncertain about their 'survival' in farming from one year to the next because of impact soil erosion. It is, therefore, likely that even if they were aware of the

medium and long-term benefits of soil conservation options, most farmers would not give high priority or value to these benefits because they occur over the long term, a period of time of little relevance to their immediate needs.

2.12.3 Soil conservation practices for soil fertility enhancements

The use of living vegetable, residues from harvested crops or all the manipulation by the farmer minus the heavy and complicated engineering works are referred to as the agronomic ways for conservation (Ajayi *et al.*, 2007). In other words, these are on-farm activities or practices that help in improving soil fertility, crop yields, and soil moisture conservation.

2.12.3.1 Cover crops

Cultivation of cover crops, such as legume plants that grows rapidly and closes the soils, play an important role in reducing the amount of soil loss and improving the physiochemical soil properties (Cobo *et al.*, 2009). Their dense canopy cover averts the rain drop impact from dislodging soil particles and helps to keep soil loss to tolerable limits, as well as helping in weeds including spear-grass (*Imperata cylindrical*) and witch-weed (*Striga hermonthica*) suppression, which are dominant especially in northern Nigeria (Onyewotu *et al.*, 2003).

Both, soil chemical properties such as the soil organic carbon, nitrogen (N) levels (by the use of N²-fixing legumes), the CEC, and soil physical properties including the rate of infiltration, amount of moisture content, and the bulk density were found to be positively influenced by cover crops (Adegbidi *et al.*, 2004; Bell *et al.*, 2014). For instance, in an investigation conducted to determine the effects of cover crops in Ibadan southern Nigeria, Salako *et al.*, (2006), found the amount of soil eroded from a monoculture plot of maize was higher 3.3 t ha⁻¹ compared to 1.8 t ha⁻¹ recorded from plots with multiple cover crops. In northern Nigeria, legumes crop was found to

contribute about 15kg/ha (range 037kgN/ha). The contribution of legume crops in fixing nitrogen into the soil depends on the specific cropping pattern and density of legume plants in the field.

A major limitation of this conservation option is the intensive growth of several cover crop species that might result in competition with food crop growth factors. Though, Odunze (2002) recorded no significant competitive effects from *p. phaseoloides* to maize, but a reduced yield of cassava was recorded. Hence, this problem can be combated by choosing compatible crops and by controlling the cover crops by timely cutting.

2.12.3.2 Multiple cropping

Multiple cropping involves different kinds of systems depending on the temporal and spatial arrangement of different crops on the same field. It has been traditionally practiced and is still very common in Nigeria, especially in the northern guinea savanna region to which belongs the study area.

Agroforestry is a collective name for a land use system in which woody perennials are integrated with crops and animals on the same land management. The integration can be either in a spatial mixture or in a temporal sequence (Kabubo-Mariara *et al.*, 2006; Kairis *et al.*, 2013). Bronick & Lal (2005) urged that the cultivation of several species diversifies production, minimizes the risk of crop failure, improves labor and nutrient use efficiencies, and contributes to soil conservation by controlling erosion and enhancing soil fertility.

Alley cropping is regarded as a system with the potential to improve the physical, chemical and biological soil properties and to increase farmer's income through additional products such as fuel wood or timber. Much research has been done in the

alley cropping with leguminous trees or shrubs, especially with a focus on improving soil fertility management in Nigeria. For instance, in an investigation to determine the level of nitrogen in alley cropping systems Kassie *et al.*, (2013), reported a lack of synchronization between crop nitrogen demand and nitrogen supply by pruning. This can be avoided by selecting the appropriate legume genotypes, the combination of selected tree and crop species, and improved management practices.

2.12.3.3 Green manure

This is an agronomic practice that involves the application of organic manure, for soil conservation to restore soil fertility (Heathcote & Stockinger, 1970; Rushemuka *et al.*, 2014). Green manure crop and compost are sources of organic manure. The green manure crops are nitrogen-fixing plants, which are grown for some period of time and they turned into the soil as sources of nitrogen and organic matter.

According to Cobo *et al.*, (2009); Hoffmann *et al.*, (2001); Odendo *et al.*, 2010) farmers use compost, or goat and sheep dung as well as cattle manure to fertilize farms. He further mentioned that potash obtained from household rubbish is also used as well as heaps or piles of rubbish are used to fertilize nearby farm plots, as the farmers were not in the habit of taking such manure to distance farms.

2.12.3.4 Bush fallowing/ shifting cultivation

The practice of allowing a farm to revert back to fertility was perhaps the best conservation method most traditions had. In other words, it means bush fallowing which was a recognized method of allowing vegetation to regenerate on a farm that has been exhausted, allowed both the vegetation and the soil to be improved. However, until recently when population pressure set in, a farm left fallow was only ready for re-cultivation after at least 10 years had elapsed. Cobo *et al.*, (2009); Odendo *et al.*, (2010), urged that the long fallow practice that was part of the traditional shifting cultivation

measure that encourages soil regeneration is no longer obtainable due to the twin problems of rapid population and the influence of urbanization in the most agricultural region of Nigeria. To this effect, improved fallows of short periods remain to be made.

A number of empirical studies have shown that improved fallows of short periods with selected tree or herbaceous species remain important as land fallow. For instance, fallowing with guinea grass (*panicum maximum*) has been found to provide the much needed organic matter to the soil (Cobo *et al.*, 2009; Kolawole, 2013; Odendo *et al.*, 2010). For improving the physical soil conditions, shrubs of woody plants such as pigeon pea (*cajanus cajan*) were found to be advantageous due to the penetration of their rootlets into deeper soil layers (Chianu & Tsujii, 2004; Heathcote & Stockinger, 1970). While, for increasing the Nutrient content and changing the quantity of available Phosphorus fractions in the soils, Leguminous fallows with *leucaena leucocephala*, *M.pruriens* or *p.phaseoloides* were reported to be of significant importance (Ajayi *et al.*, 2007; Cobo *et al.*, 2009).

2.12.3.5 Intercropping / mixed cropping

Intercropping system is a form of agronomic practices employed by farmers where different kinds of annual crops are planted in alternating rows for soil conservation to reduce soil erosion risk by providing better canopy cover than do sole crops (Kagabo *et al.*, 2013; Moges & Holden, 2007). The same authors equally maintain that sequential cropping where the second crops mature under the soil residual moisture (e.g tomatoes) also helped in the soil fertility improvement.

For instance, in an erosion measurement to determine the amount of soil fertility loss from mono and intercropping farm systems conducted by Aina *et al.*, (1979), an average soil fertility loss of 110 tha^{-1} from cassava plots and 69 tha^{-1} from maize and cassava plots were recorded. They attributed the dynamics of the high amount of eroded

sediments from the plots with the sole root and tuber crop by its slow growth and small canopy cover at the beginning of the rainy season. Growing maize between the cassava ridges increases the soil coverage and hence reduces the impact of rain (Cobo *et al.*, 2009; Kassie *et al.*, 2013).

In Nigeria, numerous empirical investigations have been conducted on intercropping of cereals such as maize, (*Zea mays*), sorghum (*Sorghum bicolor*) or millet (*pennisetum glaucum*) with herbaceous grain legumes or root and tuber crops with other annual crops to improve soil productivity and crop yields (Junge *et al.*, 2008). An investigation, for instance, to determine the effect of grain legumes in legume/cereal treatment on soil properties in the semi-arid ecosystem of northern Nigeria conducted by Odunze (2002), show that sole groundnut improved soil's bulk density at the 0 to 10 cm depth (1.26 gcm⁻³) better than the sole maize (1.34 gcm⁻³). The cultivation of legumes was also found to result in better stability of soil aggregates in the topsoil, which generally reduces the erodibility of the soil. Similarly, both the sole legumes and legumes/maize treatments were found to improve the soil nitrogen content 65.6 to 84.8%, compared 5.9% recorded from a sole maize treatments plot.

Similarly, an investigation on the influence of soil fertility was conducted by Heathcote and Stockinger (1970), where a significant measured moisture content of 14.5% to 14.7% in the top 20 cm of plots with maize, melon, and yam and from 12.7% to 14.2% on mono-cropped maize plot were recorded. The maximum soil temperature in the topsoil was affected by intercropping as it was reduced by water 2⁰C to 9⁰C compared with temperature under sole maize. The increased moisture and reduced temperature in the topsoil of the intercropped farm system maybe attributed to the shading effect of the different crop species, which reduced water evaporation from the soil surface.

Furthermore, a research to evaluated soil erosion control potentials of different treatments on herbaceous legumes (*Aeschynomene histrix*, *Centrosema pascuorum*, *Lablab purpureus*, *Macrotyloma uniflorum*, or *Stylosanthes*), cultivated as live mulch in intercropping systems with cereals was conducted by (Odunze, 2002). He found that the sediment loss from a plot with straw mulch to be much lower 0.08 tha^{-1} , compared to 0.17 tha^{-1} recorded from a plot treated with *M.uniflorum*, 0.24 tha^{-1} , from a plot treated with *S.hamata* and 0.29 tha^{-1} from a sole maize plot. Hence, the practice where straw *M.uniflorum* and live mulch are use to enhance soil fertility, were recommended especially, in the semi-arid northern zones of Nigeria.

CHAPTER 3: RESEARCH DESIGN AND METHODOLOGY

3.1 Nature of the research design

On-farm soil erosion and conservation are a phenomenon that requires not only the natural sciences analytical approach, but also the socioeconomic understanding (Boardman et al., 2003). In this regard, therefore, a qualitative approach using a case study design (multiple methods) was employed (Appendix A). The design involved two major components for gathering the necessary information (Figure 3.1). The first component of the research methodology involved field observation aimed at collecting information on farmers' fields. The second and the major component of the research methodology was the conventional household survey, using a structured questionnaire. However, informal interviews with individual heads of households, traditional community agricultural chiefs (locally titled *Sarkin Noma*), and agricultural extension agents (key informants) were carried out. The goal of the multiple methods was to obtain more information about the same fact and to increase the validity and reliability of data obtained. The vision was to best understand and come up with a valid and well-substantiated conclusion about the farmers' reasons for cultivating hill slopes, while; there are flatland areas in the research region.

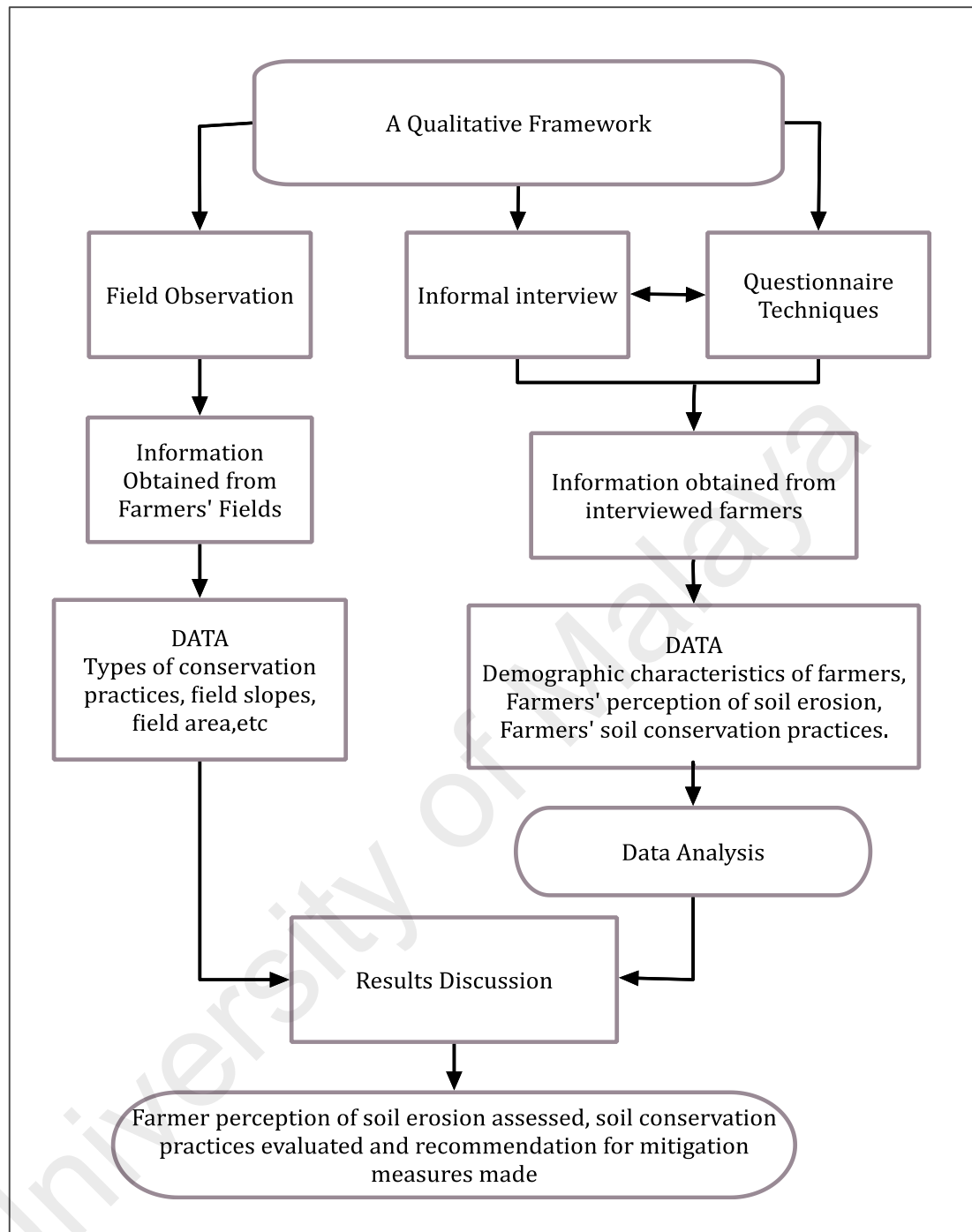


Figure 3.1: A flowchart of research design (a qualitative approach using a case study design)

Fig 3.1 shows a qualitative approach used for this study. The approach was based on information collected from the farmers and the farmers' fields. The information on the farmers' fields was collected through field observation. Information from the farmers was gathered by interviewing the farmers about their demographic characteristics, farm

ownership, distances, slope gradient of cultivated fields, farm sizes and their perception and responses to soil erosion.

3.2 Data collection

The primary objective was to gain an understanding of the prevailing water erosion problem in the research region as far as farmers' perception of soil erosion and their attempts at soil conservation are concerned. In this regard, information regarding the farmers' socioeconomic environment and geophysical environment was required for better understanding of the process. Accordingly, data collection was divided into two phases: -

- i. The first phase involved the collection of general information about the study region through; fields transect walks (observation) and informal interview with some individual heads of households, traditional community agricultural chiefs (locally titled *Sarkin Noma*), and agriculture extension agents. This phase was conducted to obtain differently, but complementary data on the same topic to best understand the research problem.
- ii. The second phase covered the farm level data collection from the sample of household head farmers. This phase was achieved by conducting interviews using a structured questionnaire. This component was conducted to understand farmers' socio-economic conditions, land ownership, agricultural products, and practices and to evaluate farmers' perception and knowledge of soil erosion and their conservation measures. The procedures used for data collection are discussed in detail in the following sections.

3.3 Types and sources of data

For this empirical study, two types of data were relevant, firstly, the primary and secondly, the secondary data.

3.3.1 The primary sources

The primary sources of data were the farmers and farmers' field. Tools used for primary data collection include personal field observation, questionnaire, and key informal interviews. Fields transect walks (preliminary/reconnaissance survey) of the study region at different times and villages were undertaken. Questionnaire surveys of 383 respondents randomly selected and made up of food crop farmers only; in addition, to in-depth interviews with the key informants were undertaken to collect relevant and reliable data. Agricultural extension agents and traditional community agricultural chiefs (locally titled *Sarkin Noma*) provided primary information.

3.3.2 The secondary sources

There is previously a wealth of information on numerous features of the study region. This contains information on farmers' socio-economic characteristics, environmental situations, and soil erosion and conservation aspects. In this regard, therefore, various publications and reports by researchers on the subject matter were the key secondary sources. The survey covered the technical parts related to the study, including soil erosion, farmers' perception of soil erosion and conservation measures used in the region. Also, are the important components of the production system and land use patterns, as well as the institutional facets such as, land tenure system; credit schemes, and policies such as environmental policy were also reviewed. Other valuable material examined included the topographical sheet covering the study area, which served as the baseline data.

3.4 Field observation

Field observation is an important technique of collecting primary data. In this regards, in order to achieve the objective concerning the first phase of data collection for this study, a transect walks off the study region was undertaken. The purpose of the study remained to gain an understanding of the study region, with respect, to the components of the agricultural system and practices, the geophysical and socio-economic situations.

During the walks, the researcher observed and took note of the level and types of soil erosion associated with water erosion, significant topography, agricultural land uses, farming systems and soil conservation practices that were dominant in the study region. The study was also used to better apprehend the socio-economic characteristic of the farmers, their attitude, and perceptions towards soil erosion, as well their soil conservation practices. Thus knowledge of these was used in refining the scope of the study problem, identifying major information gaps, and guiding the sampling process, and in designing and preparing the farm level household survey which is the core instrument for collecting information. The information gathered was triangulated with the household survey during results discussion.

3.5 Interview

An interview is one the most important tool for gathering primary data through interviewing people who knew about the problem under study. It is an important tool for gathering information in much detail to better understand people's perceptions and awareness (Marsh *et al.*, 1988). In this regards, in other to achieve the objective concerning the first phase of data collection for this study, information was obtained through informal interviews in three successive sessions. Firstly, before the questionnaire administration, secondly, during the questionnaire administration from

some randomly selected farmers' household heads. The interview sessions focused on the farmers' knowledge and perception of soil erosion; particularly their preferred use of sloping fields, their capability to recognize existing soil erosion indicators on their field, loss of soil fertility, and the use of fertilizer. The trend of rainfall over the last decade, yields, local organization, needs for monetary or technical assistance from the state and private organizations were also asked. Thirdly, after the questionnaire survey, from some agricultural extension agents and traditional community agricultural chiefs, in each of the six local government areas, that constituted the study region. Thus, the informal interview has facilitated in gathering detailed information. The information was triangulated with the household survey during results discussion. The desire for the third session was to complement and cross check the information provided by the randomly selected household heads, to ensure the validity of acquired information.

3.6 Individual farmer's questionnaire

3.6.1 Survey design and selection of respondents

In the second stage of data collection, a structured questionnaire survey design was used to collect relevant data from sampled household heads in the study region. Questionnaires are the most important tools for collecting primary data. It is widely used to obtain information about certain condition and practices to gain opinion and attitudes of individual or group (Goodman, 1997). Taking the study region as a case study, survey questionnaires are used to gather primary household data. The households in the context of this study are defined as a group of people who live together, and jointly work and depend on the same piece of land, and other production resources, such as family and hired labour. The household members in this context, therefore, have the same production goals and priorities and their decisions about farm production are guided by the same choice criteria.

Farmers' perception of soil erosion and their soil conservation measures were the central themes of the questionnaire. The respondents were asked about the relative seriousness of soil erosion problem due to the cultivation of different land use sites and their attitudes to control it. Supporting questions were asked about the preferred use of sloping fields, the trend of rainfall over the last decade, loss of soil fertility, and practice of soil conservation. Questions regarding fertilizer usage need for monetary or technical assistance from the state government, and yields, were also asked.

3.6.2 Questionnaire sampling procedure

Data was collected through a formal questionnaire survey of 383 household heads randomly selected from the list of arable crop farmers provided by Taraba State Agricultural Development Programme Office (farmer's village listing form), which was used as a sampling frame. The questionnaire was administered between July and September 2014, when the greatest amount of rainfall was recorded. The rainfall caused significant soil losses in the region, resulting in the implementation of soil conservation practices. A multi-stage sampling technique was used in this study. The sampling techniques were undertaken in four stages: (1) selection of Local Government Areas (LGAs); (2) selection of study districts; (3) selection of the study villages, (4) the selection of individual farmers.

The first stage involved dividing the study region into LGAs. The LGAs were used as clusters for sampling purposes based on their total population of household heads. All the six LGAs were selected for this study, based on shared socio-economic and geophysical features as well as their types and levels of soil erosion by water and presence of soil conservation practices.

In the second stage, from the clusters (LGAs), 18 districts (3 districts from, and constituting 30% of the districts in each LGAs) were selected by purposive sampling

technique (Table 3.1). According to Krejcie & Morgan (1970), 30% sample size is adequate to provide policy-relevant insights and answers to the main objectives of a study without involving large-scale survey. The purposive sampling was employed because of: -

- i. Attainment or status of Jalingo metropolis as both the local government and state headquarters of Taraba State, and
- ii. The presence of four districts within Jalingo metropolitan.

The most important consideration in selecting districts was their geographical location, population intensity, agricultural potential, and possibilities of representing the socio-economic characteristics of rural life in the region.

In the third stage, four villages from each of the eighteen districts sampled were randomly selected, yielding a sample size of seventy-two villages, in which the questionnaire was administered (Table 3.1) and (Appendix B). Finally, a total of 383 household heads or respondents were randomly selected by lottery method from the list of arable crop farmers provided by Taraba State Agricultural Development Programme office, and used for this research work. According to Dell *et al.*, (2002); MacCallum *et al.*, (1996); Marsh *et al.*, (1988), a sample size of 383 respondents is adequate to represent a study population of 100,000 peoples and above. Thus, given that the study region had a total population of 958,700 people in 2015 (Table 4.3), the 383-sample size taken from the population remains appropriate to represent the population and allow the findings to be generalized to the wider population. The proportion of these respondents (383) in each sample village was obtained using the Cochran 1977 proportional allocation techniques, formula, thus:

$$nh = \frac{Nh \times n}{N} \quad (3.1)$$

Where, nh = the number of the individual sample villages

Nh = the number of farmers in the individual village

n = the number of questionnaires to be distributed to the sample villages.

N = the total number of farmers in the sample villages.

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Table 3.1: Number of sampled districts, villages and households in each cluster (LGAs)

S/n	LGA	Total number of districts	Proportion sampled districts at 30%	Range of villages in each district	Number of villages sampled from each district/ LGA	Range of households in each village	Total number of sampled households in each LGA	% of total number of households sampled from each LGA
1	Ardo-kola	10	3	21-40	4 x3 = 12	309-653	64	16.7
2	Jalingo	10	3	21-47	4 x3 = 12	375-721	72	18.8
3	Lau	10	3	21-47	4 x3 = 12	305-657	66	17.2
4	Karim-Lamido	11	3	21-47	4 x3 = 12	342-847	55	14.4
5	Yorro	11	3	21-42	4 x3 = 12	320-569	51	13.3
6	Zing	10	3	21-46	4 x3 = 12	310-785	75	19.6
	Total	62	12		72		383	100

3.6.3 The structure of the questionnaire

The questionnaire contained different types of questions including, open-ended response questions which seek respondent's opinion (subjective/opinion questions), close-ended response questions which include predetermined responses, (pre-coded questions), and factual questions envisioned to obtain facts, including quantities (outputs) and years (age) While, responses to questions that required the collection of information that encompassed several segments were organized in a tabular format.

3.6.4 The questionnaire formation

The questionnaire consisted of 75 questions that were organized into six sub-sections (Appendix C). Each sub-section deals with different types of information, and considerations were given to the easiness to ask questions, to record the responses, and the flexibility in designing the research questions. The sub-sections are as outlined below: -

- i. Households' demographic status: - age, sex, education and marital status, family size, family labour and farm income.
- ii. The information on farmland ownership: - method of farmland acquisition, farm size and a number of plots (s), farm distance, farming experience and the annual output
- iii. Perception of soil erosion: - The respondents were also asked about the relative seriousness of the soil erosion problem due to different land use sites, the preferred use of sloping fields; and loss of soil fertility. Supporting questions were asked about whether the household heads were aware that erosion was taking place, household perceived reasons for the development of erosion indicators.

- iv. Households' conservation practices: - whether they farmers' use soil conservation practices, types of practices used, and effectiveness of soil conservation practice their level of awareness and constraints to their adoption if any.
- v. Households' farm characteristic (farm soil fertility level): - whether households use fertilizer, types and the quantity of fertilizer usage.
- vi. Institutional support: - support received, extension visit and credit support from the government.

Although the order of the questions in the questionnaire starts from personal characteristics to more general and specific topics, these were not asked in the same sequences. In every case, questions regarding the relative seriousness of soil erosion problem and soil conservation were asked first. The questions in section one were always the last to be asked. This arrangement was desired to get accurate and unbiased information and not to offend the respondents by asking personal questions at the start of the interview.

However, before the questionnaire was administered to sample household heads, a test survey was conducted in one of the study villages in each of the six local government areas that made up the study region. The goals were to evaluate the accuracy of the question and the nature of the respondents, the structure of the questionnaire and to estimate the time required to fill a single questionnaire. The motives was to check clarity; relevance and sequence of the questions and to identify miss items, so as to make some minor modifications, prior conducting the full survey. In addition to this, was to re-acquaint the research assistants, with the nature of the terrain and the culture of the people. After the pre-testing, the questions were revised, and the questionnaire finalized. The survey was conducted from July through September 2014.

3.6.5 Recruitment and training of enumerators

Enumerators were drawn and recruited from the 400 level students of the department of geography, Taraba State University, Jalingo, to carry out the interviews. The selection was informed by the fact that enumerators determine the success of interviews and the quality of the data to be collected. The recruited enumerators were thoroughly trained to carry out the interviews. Important considerations for the selection of enumerators were their personality (including hard working, friendly, patient and open-minded), local knowledge (including language and familiarization with local farm conditions), and education level (high).

Three days prior to the survey were spent on enumerator's training. The objectives of training were; (1) to provide orientation to the purpose of the research and objectives, the study area and organization of survey, (2), to provide instructions for interviews techniques including how to effectively communicate with respondents and how to ask questions, and finally, to familiarized the enumerators with the questionnaire that included elaborations, clarifications and tips on different questions to make sure that enumerators understand all the questions, have clear and consistent views on what information is needed and interpretation of questions, that is, how questions should be asked, and how and where to record the responses. This was carried out by going through all the questions, interpreting the intention of each question and the type of answer expected.

3.6.6 Structure of interviews

Each of the household heads sampled was visited and interviewed both during the pre-test and actual field work; in either their respective homes, in the farms while plowing the fields or in village shops. Each one of the respondents was introduced to

the objectives of the study, and his consent to participate was sought. All the respondents willingly participated; however, a few were more curious and wanted to know what this study meant to them, and what they might get. The nature of the study was made clear to them. An average of 15 household heads was interviewed per day, and one interview took about 70 minutes. In male-headed households, both husband and wife were encouraged to participate in the interview.

Each day, at the end of interviews the questionnaires were collected from the enumerators and checked for completeness, errors, omissions and irrelevant responses. Identified errors and problems were discussed with the enumerators and where possible corrected immediately. In a few cases, respondents had to be re-interviewed. Difficult aspects of the questionnaire were also revisited, discussed and re-emphasized. Some problems were encountered during the field implementation of the household's interviews:

- i. There were a few occasions where the respondents were not cooperative and/ or refused to be interviewed. This happened when the purpose of the interview was not clear to the respondent or when they are not interested in participating in the interviews. Using the reserve list to replace them solved this problem.
- ii. Similarly, there were few occasions where respondents were more curious and wanted to know what this study meant to them, and what they might get. In such situation, it was clearly explained to the respondents that this study is purely of academic interest.
- iii. Another problem related to this was a missing respondent. This happened because of some emergencies such as a death in the family and sickness. In about three occasions, the households included in the sample list were not heads

of households. In such cases, these respondents were replaced with their respective heads of households, either right away or an appointment was made at the later time.

- iv. In most households, the enumerators spent more time than anticipated, because either, the respondent had prepared some food to share with the visitors (it is common in the study area to give some food to visitors, and refusing is considered disrespectful), or was interested in discussing other things being the interview.
- v. On a few occasions, there were cases where it was difficult for the respondents to provide quick information on farm income, acreage and the annual output in last four years. In this case, the respondents were given ample time to recall their income, acreage, and the annual output.
- vi. Questions that required respondents to recall some details such as farm income, expenditures, and a number of extension visits annually, which varies from year to year due to changes in environmental factors, was difficult to calculate for an illiterate farmer. Influenced by some assumptions, they respondent may deliberately underestimate his income or output from his farm.

3.6.7 Accuracy and Reliability of information from interviews

Successful data collection is determined by the extent to which the information collected is accurate and reliable. Therefore, the inaccuracy and unreliability of data collected were attributed to the following aspects; collecting of inadequate and wrong information, enumerators' bias and sampling errors.

There were cases where it was difficult for the respondents, particularly the untrained once to provide accurate information on questions that required them to recall some details, such as farm income, and expenditures annually which varies from year to year

due to changes in environmental factors. Accordingly, given the small-scattered fields owned by the farmers, due to inheritance in the study region, it was hard for the peasant farmer to remember the entire farm plots and their acreage (reliable size). Therefore, the farmers may underestimate or overestimate both farmland numbers and acreage due to their ignorance.

Similarly, most farmers do not measure the amount of crops they harvest annually. In most cases the harvested crops are kept in traditional granaries and use little by little for food and sale, and, only on few occasion, are the harvested crops kept in bags and other types of storage containers. Consequently, the enumerators had to convert the different local units into standard units (kilograms) using the best estimate possible. In this case, conversion errors are possible.

Questions that mentioned money were in most cases difficult to register, and/or respondents misinterpreted the information provided. This included the question dealing with income from their farm produce (9) and the one on the kind of help needed to improve soil conservation (75). The responses given to these questions were in some cases influenced by the anticipation that the questions were meant to assess their eligibility for some loan/financial support from the government or donor agency. To avoid this, enumerators were asked to make these questions as clear as possible and explained beforehand that no assistances motives are behind these questions. Therefore, the accuracy of responses depended on the enumerator's ability to elaborate/ explain the information.

Sensitive information such as that related to income (off-farm income) and output brought the fear that such personal information can be disclosed to the public. To reduce wrong information, indirect questions were used to verify the information provided and

in some cases probing was used to ensure that the respondent was not misleading the enumerator. Related to this, though not encountered often, is the situation where the respondents showed a non-cooperative attitude, was tired, distracted or in a hurry due to having a busy day, lack of interest in the interview or mistrusting the survey objectives, therefore providing doubtful information. Where this situation occurred, the effort was made to identify the cause of poor cooperation and rectified. In only one case, the interview was terminated, and the respondent was replaced. Also, enumerators were asked to indicate this kind of behavior in the last section of the questionnaires. Questionnaires from such respondents were scrutinized, to see if serious inconsistency in responses is found, a replacement was also sought.

Enumerator's knowledge of the local situation, including language, interest, and motivation influenced the quality of information collected. Inaccuracy in information caused by the enumerator bias may include a). Enumerator inability to invoke respondent's interest, by asking questions improperly, therefore missing the focus, b). Enumerator expecting particular answers on the basis of earlier responses pattern, thus recording it without confirmation, c). Enumerator's miss recording information in the questionnaire. These problems were minimized through on-job training, close supervision and frequent inspection of the questionnaire by the author.

3.7 Data management

After the fieldwork, the next step was to summarize and organize the information collected into a form that can be analyzed. This task involved two steps:

The first step involved translating various questions into variables. The variable formulation process also included the formation of sub-variables for some of the pre-coded questions with more than two responses for the easiness of analysis; these were

later consolidated into one meaningful variable. For open-ended questions, such as the major causes of erosion, all answer given by the respondents was listed. The most frequent answers were identified and used to derive variables for these questions. The second step was assigning codes to responses from different descriptive questions and deriving appropriate values for some of the continuous variables such as farm income. For questions with two pre-coded responses such as the sex of the head of the household, marital status, the same questionnaire codes were retained.

All the variable/sub-variables together with their respective codes or values for continuous variables were posted into the computer spreadsheet (Lotus) as raw data for further synthesis. A detailed description of the variables used in the analysis is provided in Chapter 5.

3.8 Method of data analysis and presentation

Because of the nature of the issue under investigation, the researcher mainly used qualitative description to interpret and present the data gathered from different sources. Descriptive statistical analysis of the Statistical Package for Social Sciences (SPSS 22) software was used to analyze the questionnaire data. The analysis method used descriptive statistics, primarily frequencies converted to percentages. A chi-square analysis was used to examine the association between farmer adoption of soil conservation measures and their perception of water erosion and fertility depletion as a problem. The associations between farmer perceptions of the trends of soil erosion and fertility depletion versus their levels of adoption in soil conservation were examined using the Chi-Square and Spearman correlation, because the data are not normally distributed. The findings of the study were mostly presented in tables and figures.

3.9 Summary

This chapter is intended to present an overview of the data collection procedure and the design of fieldwork. Data collection was divided into two phases, namely, the preliminary survey that includes secondary data collection, field reconnaissance study, and the household interviews.

The main objectives of the preliminary survey were to provide an understanding of the study area and establishing a good rapport with local people. The survey was also used for collecting information useful for refining the focus of the study, guiding the selection of the study area and designing the household interviews.

Households' surveys were conducted using a structured questionnaire. Questions addressing the objectives of the study based on the analytical framework developed in chapter 5 were constructed and administered to a sample of 383 household heads in the study region. The questionnaire was used to collect information on household characteristics, socio-economic, their perceptions of the soil erosion problem, the types of soil conservation practices used by farmers, and their effectiveness. Furthermore, information on the institutional and physical factors relevant to explaining the perceptions of the soil erosion problem, adoption of soil conservation measures and conservation effort was collected.

The households' surveys were preceded by sampling or selection of the study region. This includes a selection of representative districts by purposive sampling techniques, study villages and sampled household heads. The main criteria for study region selection were its share socio-economic and geophysical features. 72 villages were selected to represent the villages. The number of household heads selected from each village was proportional to their population size.

Similarly, a questionnaire pre-testing and enumerators training preceded the farm-level household surveys. The pre-testing was conducted to check the validity of the structure of the questions in the study villages. Training of enumerators was focused on questionnaire familiarization and interviewing techniques to ensure that the enumerators understood all the questions and adequate and reliable information was collected.

During the interviews, various problems were encountered. Different ways to rectify these were looked for as much as possible to reduce data inaccuracy. These include replacing respondents (e.g., non-head of household and uncooperative respondents), using probing techniques and indirect questions to clarify doubtful responses and clarifying suspicious thoughts and misinterpretation emerging from some of the questions. Also, frequent checking off completed questionnaires and on-job training for enumerators are additional strategies used to improve the quality of information collected. Information collected from the household interviews was synthesized and organized into a form that can be utilized to address the study questions. This task involved translating the questions into variables and assigning values to variables created. This was a preliminary step towards further synthesis and data analysis presented in Chapter five.

CHAPTER 4: STUDY REGION

4.1 Geographical Location

The study region, the Northern part of Taraba State ($6^{\circ}30^1$ and $9^{\circ}36^1$ N; $9^{\circ}10^1$ and $11^{\circ}50^1$ E), is situated in North-Eastern Nigeria, along the Nigerian-Cameroun border (Figure.4.1). It is bordered on the North by Bauchi State, in the East by Adamawa State and Plateau State to the West, and in the Northeast and Southwest by Gombe State and Gassol local government area respectively. The study region has a total surface area of $16,719\text{km}^2$, a total population of 785,912 inhabitants in 2015, with a projected annual growth rate of 3.1 percent (NPC, 2016). Thus, the area delineated as the northern part of Taraba State can be described as a unit area with same common geographical characteristics in terms of climate, vegetation, and soils.

Administratively, the study region falls into six Local Government Areas of Taraba State: Ardo-Kola, Jalingo, Lau, Karim-Lamido, Yorro, and Zing. There are a total of sixty-two (62) districts in the six local government areas, with Karim-Lamido and Yorro, local government areas, eleven, Ardo-kola, Jalingo, Lau, and Zing made up of ten districts each. Within each district, there was a range of between 21 to 47 major villages and each village have approximately a range of between 305 to 874-farm families (Taraba Agricultural Development Programme, 2014) village listening form. According to TADP's data (2014 village/farmers listing form), the study region has a total population of 365,709 household heads, of these proportions, 365,294 were male and 415 female household heads.

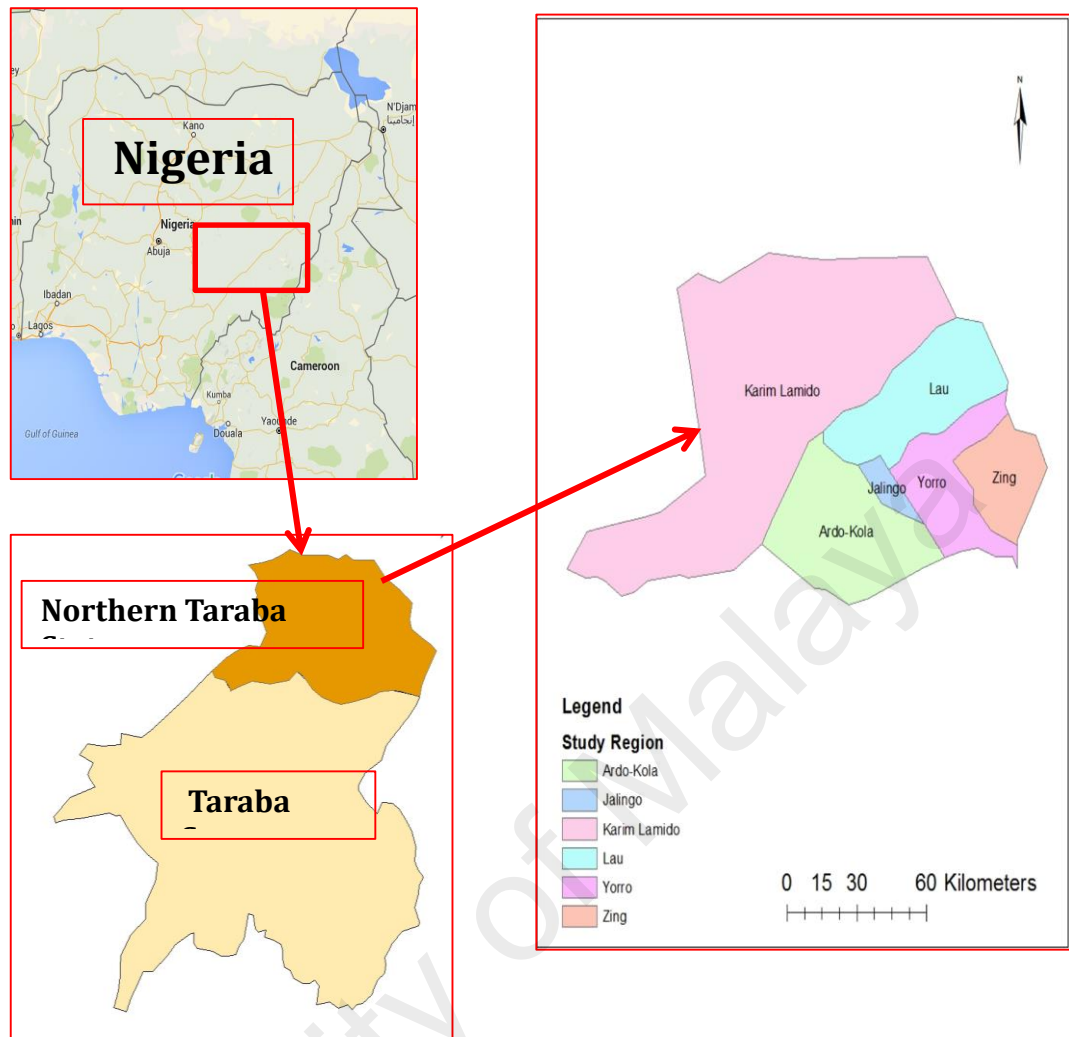


Figure 4.1: Map of the study region showing LGAs

4.2 Geology

The study region is underlain predominantly by the Precambrian granite rock of the basement complex. According to EO & Ngwu (2013), these rocks were formed from series of orogenic cycles within the mobile belt of Central Africa. Granitisation by the intrusion of granites transformed the older rocks into oriented biotite granite, biotite and porphyroid-granite and alkaline granite, which are hard crystalline cratonic basement. The basement complex here, consist principally of undifferentiated igneous and metamorphic rocks of Pre-Cambrian age. This includes granite, gneisses, and migmatites. Others include schist, phyllites, quartzites and metamorphosed derivatives of ancient sediments. However, amphibolites, diorites, gabbro and marble are present in some areas as intrusions, but widely distributed are the pegmatites.

A thin layer of the weathered mantle and some alluvial material further characterizes the basement complex. This mantle has an average thickness of fifty feet, but extends to a depth of two hundred feet in some areas (EO & Ngwu, 2013; Kundiri *et al.*, 1997). The geological structures that predominate are; dykes, quartz, veins, folds, and shears belonging to the Cameroon Volcanic Line. These are instrumental in the nature of relief and soils of the area that make the region different from the surrounding regions. Thus, the nature of the geological structures gave the research region two broad relief configurations highland/mountain range and lowlands/flatland (Iloeje, 2001; Udo, 1970).

4.2.1 Topography

The highlands/mountains ranges occupy the Eastern region of the Benue valley, stretching towards the north, from the South through the Eastern part of the study region in chains of mountains, forming part of the northeastern highlands of Nigeria (Adebayo

& Tukur, 1991; Iloeje, 2001; Udo, 1970). These ranges are assemblages of numerous granite outcrops and consist of dissected surfaces, and steep slopes, with elevation ranging from an average of 1,800 to 2,400 meters above sea level (Figure.4.2). The highlands constitute 30% of the region's total land area (Figure.4.3).

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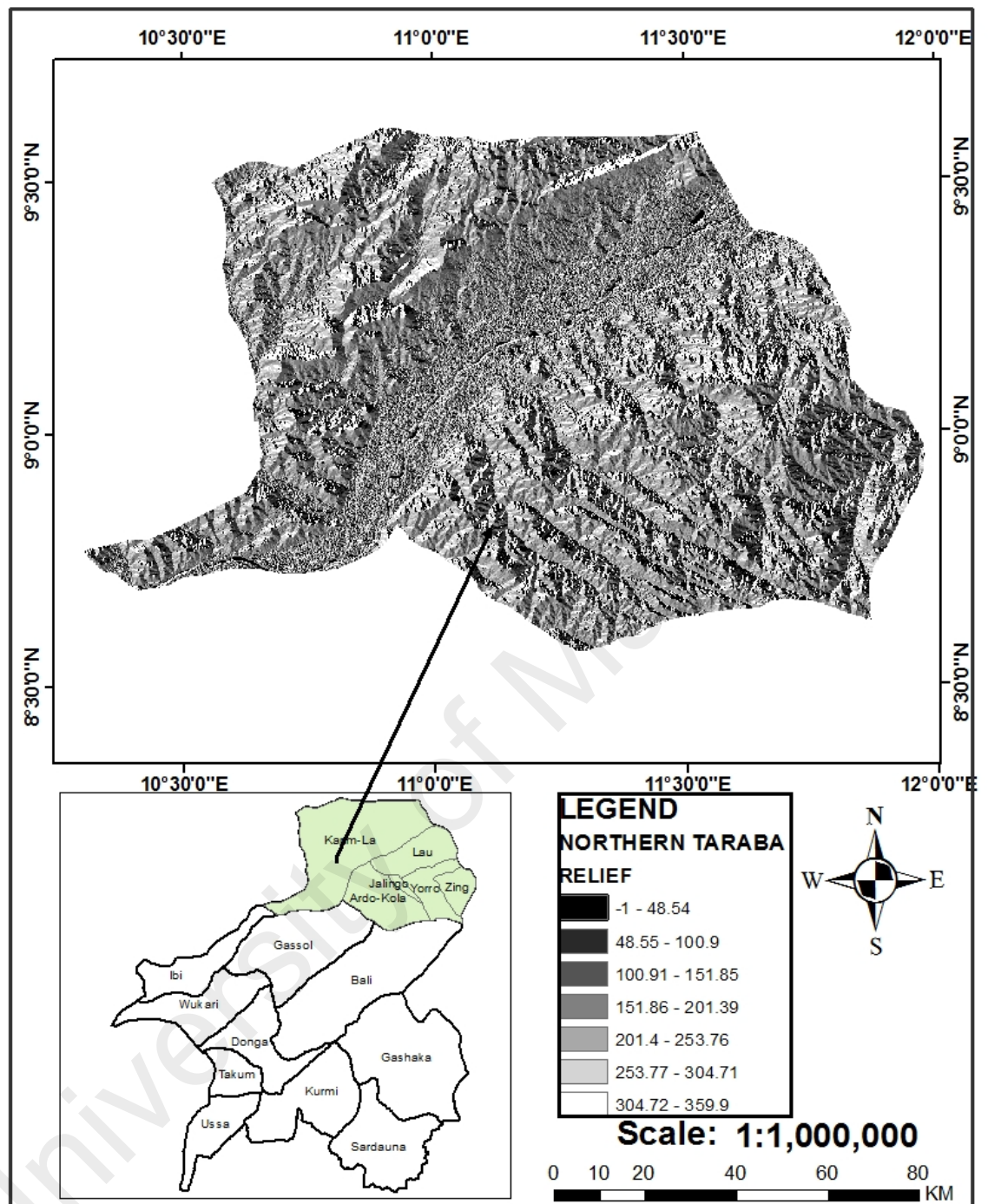


Figure 4.2: Map of the study region showing Relief configuration

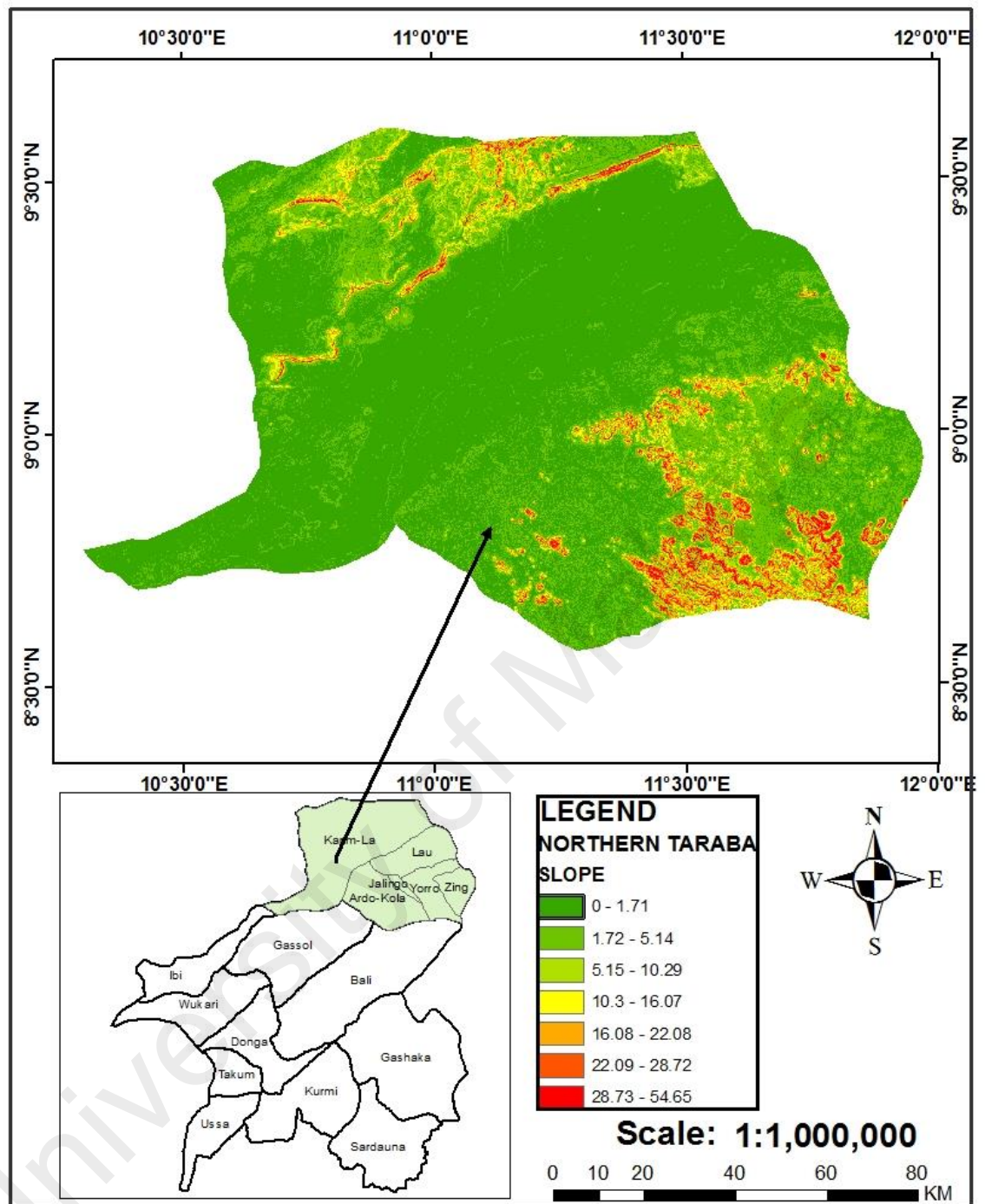


Figure 4.3: Map of the study region showing Slopes Areas

4.2.2 The Lowland / flatlands

The lowland/flatland area which occupies about 70% of the region's total land area belongs to the plains of Benue valley, popularly known as the undulating lowland of the southeastern Muri-plains (Iloeje, 2001; Udo, 1970). It stretches from the north to the western part of the study region. Physiographically is very extensive and generally gently undulating to almost flat. In another word, the surface area is gentler and flat, occasionally interrupted by hilly and rocky outcrops. The hills vary from an isolated inselberg to dotted areas of hilly terrain made up of the most resistant granites, quartzites, and quartz schist (Udo, 1970). The flatland region consists of deposits of tertiary rocks, with an altitude fluctuating between 50- 500 meters above sea level (Iloeje, 2001).

On the basis of their relative slope position (Iloeje, 2001), further sub-divided the lowland into two plains, the upper and the lower plains. The upper plain consists primarily of areas within an elevation range of 350- 500 meters above sea level. It covered an extensive area in which basement complex igneous and metamorphic rocks have been eroded and formed rolling. The lower plain covered areas mostly within the extensive fadama swamp of the Muri plains, with an altitudinal range of 50-240m (500-800ft). The lower plain region is very thinly settled and virtually uncultivated and underlined by sedimentary rocks (Iloeje, 2001; Udo, 1970). Denudation actions by the Benue river system liberate enormous alluvial sediments to form extensive flood plains along the trough.

4.3 Drainage systems

The topography of the research region is essentially a picturesque mountainous land interspersed by undulating hills with many interlocking spurs on a small scale (Iloeje,

2001; Udo, 1970). With the wavy nature of the topography, a dendritic system of drainage has developed. The region is, therefore, well drained by fast flowing seasonal streams and rivers emptying into River Benue.

The Benue River, which originates from the Adamawa plateau of Northern Cameroon cut across the western part of the study region. The river empties its water into the Atlantic Ocean after its confluence with the Niger River at Lokoja. Notable among the rivers and streams, which flow into the Benue River in the study region, are Appawa-kumi, Garin Sarki, kunini, Didango, Jen, and Jalingo (Iloeje, 2001; Udo, 1970). Both the Benue River and its tributaries constitute a major hydrogeological basin, which incorporates Benue River basin and tributaries. The total catchment area of the Benue River is about 1400km².

4.4 Climate

The climate of the study region is characteristic of a humid tropical region, which is determined by the movement of the Intertropical Convergence Zone as well as the effect of relief (Ati *et al.*, 2002; Salzmann *et al.*, 2002). The climate is characterized by alternating periods of dry and wet spells. The major climatic elements that influence the climate of the region and affecting the agricultural system and practices, are temperature and rainfall. These two elements affect the other weather elements such as relative humidity and dew. There is, however, no detailed data on some of the climatic elements.

4.4.1 Rainfall

The study region records higher rainfall than the surrounding region, due to orographic factor, which induces orographic rainfall (Fasona & Omojola, 2005; Watts, 2013). Rainfall is uni-modal with the wet season extending from April to October, and a

peak in July and August. The onset of the rains is the end of the dry season, over which all cultivated fields stayed as communal grazing grounds, and the soils exposed to the vigorous sun. This means that the soil is barely covered by the beginning of the rainy season, making it highly vulnerable to water erosion.

According to TADP's data, the mean annual rainfall of the study region is 1507mm. The average annual rainfall between the years 2005 up to 2014 is 1384.5mm, with a maximum average annual rainfall of 1638.4mm in 2012 and a minimum of 1125.4mm in 2010 (Table 4.1). The rainfall is spread, but not evenly distributed, over seven months, April to October. The onset of the rains starts in April with the low amount, but increasing gradually reaching the maximum in August. The amount drops also gradually with cessation in October (Figure.4.4). The pattern creates marked dry and rainy seasons from November to March and April to October respectively. The rainy season (April- October) is more dependable for farming activities. Thus, it is during this period that the major agricultural activities, such as plowing, sowing and weeding are performed. Also, areas at the slope and foot of the mountain hills experience increases in run-off resulting in flooding, to the extent that, farms are destroyed yearly.

The daily rainfall (Appendix D) reveals that the area has steady average rainfall amount. In 2005 the average rainfall was 1332.9mm. In 2014, ten years after, the average rainfall for that year was 1507.1mm. These amounts, however, are received mostly in the months of June-September indicating that the rainfall intensity and amount are higher in these periods (Figure. 4.5).

Table 4.1: 10 years monthly rainfalls records of the study region (2005-2014) Zing Main Met. Station (8°58¹N, 11°45¹E, 1050m above sea level)

Months	Rainfall (mm)											
Months	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Total	Aver.
February	0	0	0	0	0	0	0	0	0	0		
March	0	0	0	0	0	0	0	0	0	0		
April	76.8	41.4	166.0	50.2	25.2	48.7	49.6	45.2	49.6	152.8	705.5	70.6
May	110.1	126.5	189.0	48.5	100.1	112.0	95.3	73.7	95.3	156.2	1106.8	110.7
June	205.2	234.0	189.0	188.1	182.3	236.3	305.4	229.7	270.5	276.8	2317.3	231.7
July	273.3	276.3	366.3	252.1	135.4	228.8	250.4	415.0	488.4	283.8	2969.8	297.0
August	346.7	396.1	239.5	283.9	275.5	245.5	488.4	301.1	305.4	446.3	3328.4	332.9
September	230.5	276.0	175.5	265.1	431.9	182.5	183.3	439.6	183.3	150.2	2517.9	251.8
October	95.5	59.2	133.0	55.0	174.2	69.1	84.0	134.1	84.0	78.6	966.7	96.7

Table 4.1: 10 years monthly rainfalls records of the study region (2005-2014) Zing Main Met. Station (8°58'N, 11°45'E, 1050m above sea level) continued

Months	Rainfall (mm)											
Months	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Total	Aver.
November	0	0	0	0	0	0	0	0	0	0		
December	0	0	0	0	0	0	0	0	0	0		
Annual Total	1332.9	1382.5	1458.3	1142.9	1324.6	1125.4	1456.5	1638.4	1476.6	1507.1		
	G total	13845.2										
	Mean	1384.5										

Source: calculated from data obtained from Taraba State Agricultural Development Programme's Meteorological Station, Zone 1, zing

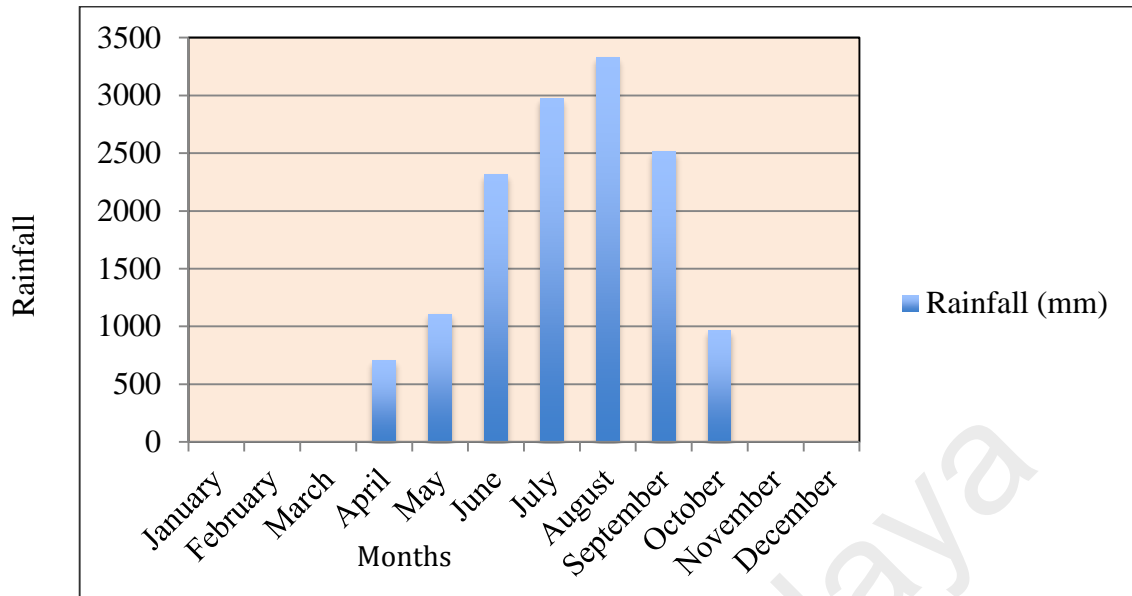


Figure 4.4: 10 years average rainfall data for study region (2005-2014)

Table 4.1 above illustrates the type of rainfall that is concentrated into a part of the year, which is typical of tropical climate. The distribution pattern of the rainfall is uni-modal and can be seen to be concentrated within a period of seven months, that is from April to October and the rest of the month (November to March) are without rain (Figure 4.4)

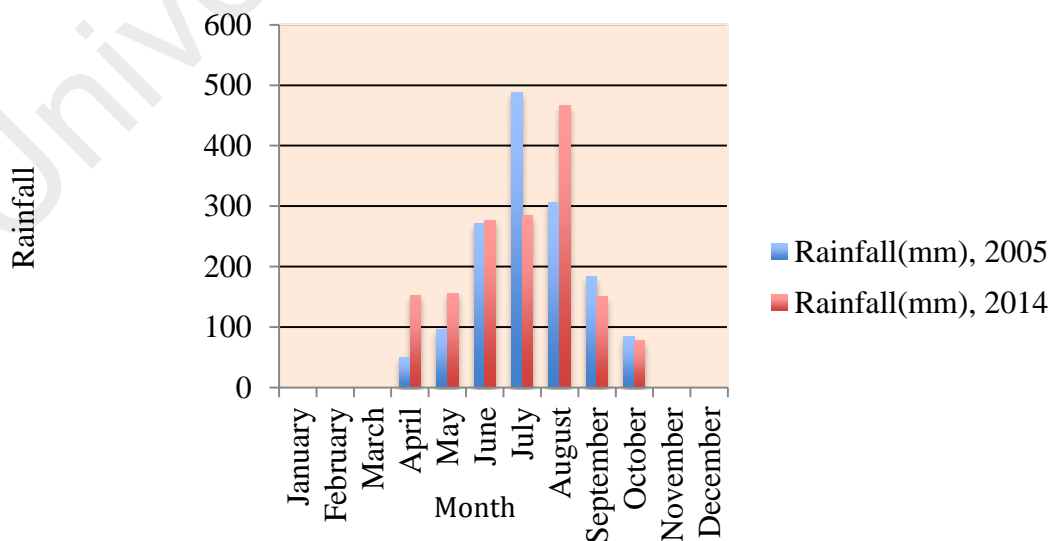


Figure 4.5: Mean Daily Rainfall (mm) of the study region for 2005 and 2014

4.4.2 Temperature

The temperature of the study region is characteristically of a montane climatic feature (Odjugo, 2010). The average temperature regime is generally low to moderate throughout the year, with the average maximum temperature 32°C and minimum temperatures 20.2°C (Table 4.2). These values are, however, slightly higher than 30°C and 18.9°C respectively, for the average maximum and minimum temperatures reported by Kowal & Kassam (1977), for the study region 40 years ago.

Figure 4.4 below indicates, low-temperature regimes are experienced during the months of July-January, while the months of February-June experience moderate weather. This is so because, though the area receives high solar radiation and evenly distributed throughout the year, the low to moderate temperature could be as a result of the effect of altitude, which lowered the temperature of the area more than the surrounding regions, rainfall and the northeast wind that blows across the region during the peak of the dry season. Rainfall lowers temperature through its cooling effect and the North East wind, which blows from the cooler dry region, has cooling effects.

The dry season in the study region begins in November and terminates in March, with a peak in January and February (Cline-Cole *et al.*, 1990; Heinrich & Moldenhauer, 2002). Earth temperature at 0-20cm soil depths was 25-30°C. The mean annual evaporation is approximately 10mm; relative humidity could be as high as 77.9% and as low as 16.3% between the months of August/September and February/ March, respectively (Ati *et al.*, 2002; Cline-Cole *et al.*, 1990). The area receives high radiation of 5.7 hours per day and moderates to light wind speed/run (Fasona & Omojola, 2005; Odjugo, 2010).

Table 4.2: Mean monthly maximum, minimum and average temperature in the study region

S/N	Months	Max °C	Min °C	Average °C
1	January	31.8	12.7	22.3
2	February	33.1	14.3	23.7
3	March	35.8	20.6	28.2
4	April	36.0	24.7	30.4
5	May	34.6	23.8	29.2
6	June	31.9	23.0	27.5
7	July	28.7	22.2	25.5
8	August	27.9	21.9	24.9
9	September	29.2	21.3	25.3
10	October	31.3	20.5	25.9
11	November	32.5	18.4	25.5
12	December	31.7	18.6	25.2
13	Total	383.8	242.1	313.6
14	Average	32.0	20.2	26.1

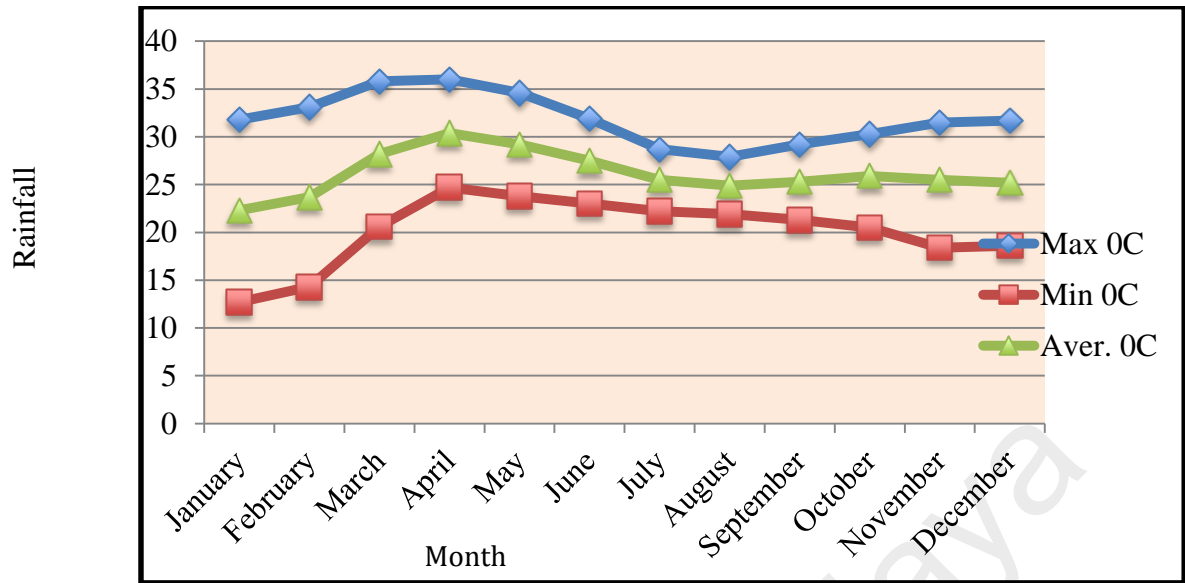


Figure 4.6: Average temperature data for 10 years (2005-2014) of the study region

Appendix E and Figure.4.7 is the mean monthly temperature of the research region. This appendix and figure show that there is almost even distribution of temperature on a daily basis. However, slight disparity between the months of February to May, where the temperature is high, and July to January with moderate temperature were recorded. The moderate temperature could be due to the impact of rainfall effects and the North East wind that blows across the region during the months of June – October and November to January respectively.

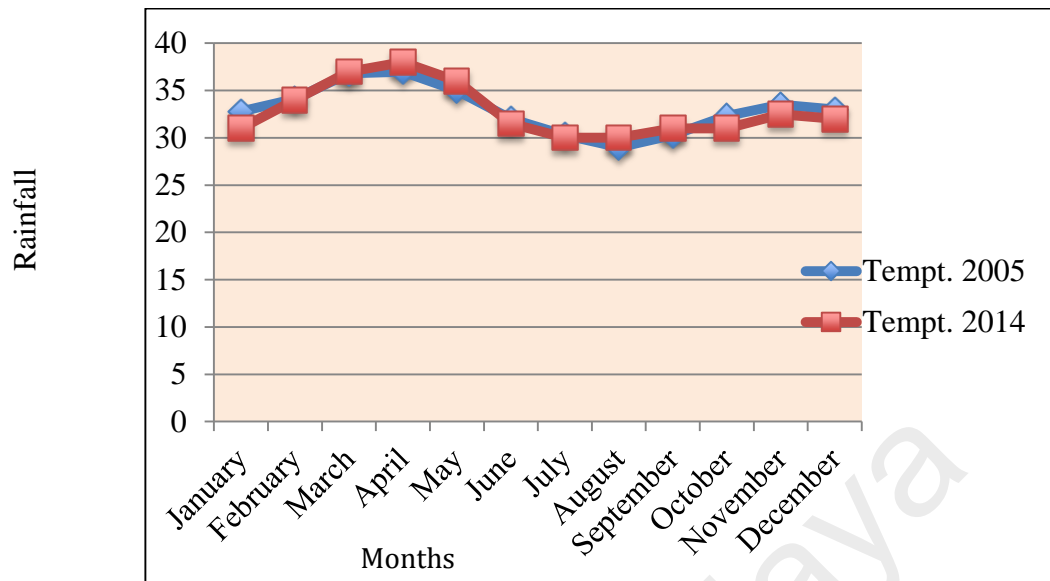


Figure 4.7: Mean monthly temperature °C of the study region (2005 and 2014)

4.5 The Soils

Soil is one of the vital natural resources of the study region that provides the basis for human living. It is on it that most of the people in the region depend on for their livelihood being an agrarian region. Soil is a composition of weathered rock materials, organic matter, water, minerals and air, thus forming a very important medium for plant growth (Banwart, 2011; Doran & Parkin, 1994). Soils, however, vary in their texture, colour, structure, mineral contents and water holding capacity. These physical properties collectively form the basis for their classification. The soils of the study region are a function of the underlying rock, the seasonality of rainfall, topography (slope) and the nature of the vegetation (Heathcote & Stockinger, 1970). They are derived from the basement complex formations (granite, migmatites, and gneiss).

Soil types are predominantly ferruginous tropical soils and lithosols of Nigeria, based on the genetic soil classification (FAO, 2007). The soils differ in colour, texture, depth, organic matter content and water holding capacity due to the configuration of the area. The color of the soils varied from dark to brown or reddish brown over the basement

complex rocks. The soils contained an appreciable amount of clay 'feel' loamy and are generally coarse, stony and shallow with almost undefined profiles on the hill slopes, and mostly sandy-loam, moderate to coarse in texture and well drained with defined horizon boundaries at the flatland. The soil types contain much oxide of iron and aluminum, which are responsible for their varied colourations based on proportion. The oxides also serve as cementing agents that cause the occurrence of the soils as mottle and concretions.

As a result of chemical weathering of the parent rocks (granite, migmatites, and gneiss), which are rich in feldspar, mica, and hornblende, the soils are composed of metallic minerals that are vital to plant growth, but susceptible to erosion, especially on hill slopes and flooded plains, where land is used beyond its capabilities, using techniques of soil and crop management that are ecologically incompatible (Kundiri *et al.*, 1997; Naibbi, 2015; Roma, 2008).

Ferruginous tropical soils are soils derived from basement parent rock material. The soils are mostly sandy-loam and moderate to coarse in texture with clay-rich base status. They soil types are alkaline in nature, with a pH values of between 5.1-6.1, moderate organic matter content, low cation exchange capacity, and water retention capacity (Kundiri *et al.*, 1997). The soils are well developed structurally as is obtained in most regions of the country or elsewhere in the tropic. The well-structured development of the ferruginous soils could be attributed to their formation on low elevated land. Ferruginous tropical soils are predominantly found in Ardo-Kola, Lau, Jalingo Yorro and Zing local government areas and covered about 55% of the study region (Heathcote & Stockinger, 1970). Being well-drained and moderate organic matter content, they support the growth of annual crops such as maize, sorghum, groundnuts and other few annual crops

Lithosols are soil groups characterized by an incomplete solum or has no clear expressed soil morphology and consisting of freshly and unperfected (unprotected) weathered rock fragment taking into the group of Azonal soil. They are generally shallow with less developed profiles, less than 10cm depths, due to their formation over the sloppy hard rocks of the mountains. Their organic matter content is moderate to low. This is probably due to the nature of the scanty vegetation over the rocky terrains. The soils are acidic as a result of the parent materials from which they are formed, having more than 65% silica content. The soils generally are deeper at the foot of the hills and thin out up to the slopes. Lithosols are found mostly in Zing, Yorro, Lau and Jalingo local government areas, and they cover more than 45% of the study region (Heathcote & Stockinger, 1970).

The two types of soils category in the study region offer great opportunities for the production of varieties of crops in the area, but certain natural and socio-economic factors may influence their full development and or utilization. However, the soils of this region have rendered and still rendering their services to the people of the area through their production capacity and sustenance of the growing population.

4.6 Soil degradation

Soil degradation is the reduction in the production capacity, resilience, and resistance of soil, which leads to a decline in quality and productivity exhibited by weak soil structure, low organic matter content, low water retention capacity and generally declining productivity. A number of factors are responsible for soil degradation. These include natural and socio-economic factors. Among the natural factors are rainfall, earthquake, volcano, landslide, drought, desertification, soil erosion and flood. These factors destabilize or weaken the soil structure, remove the protective cover of the soil, deprive the soil of its organic matter or carry away the valuable constituents of the soils.

The soils of study region experience little, or none, of some of the natural factors on a scale that degrade the soil. Apart from the occasional flood experienced that washed away farmlands, there has not been any case of volcanic eruption, earthquake, tsunamis, landslide, desert encroachment and drought reported in the area. The major natural factor that degrades the soils of the study region is rainfall that causes soil erosion.

The impact of water erosion on the soils of the study region is observable. Sheet, rill, and gully erosion are the three common forms of water erosion and occur in varying degrees in different parts of the region. Sheet erosion is common in the gently undulating terrains. Rills erosion develops, after the sheet erosion at the foot and the slope of the hills throughout the region while, gully erosion in steep hill slope sites.

Soil erosion in the study region is being exacerbated by topography, rainfall intensity, and socio-economic activities. The slopes, which dominate the regions, accelerate runoff, which subsequently encourage soil erosion and gully formations. The region has a high rainfall intensity of 18-25mm (Heathcote & Stockinger, 1970; Ijere *et al.*, 2014; Roma, 2008). This high rainfall intensity makes the area more vulnerable to soil erosion.

Unrestricted human activities in the form of excessive deliberate bush burning, overgrazing, fuel wood harvesting, conversion of hill slope areas for agriculture and continuous cultivation have contributed to the acceleration of soil erosion in the area by removing the protective cover of the soil thereby exposing the soil to the vagaries of weather.

Also, cultivation of hill slopes and flooded environment accelerate loosening of the cohesion of the underlying support from the base and such initiates erosion from the base. Similarly, on the steep slope, the velocity of overland flow is relatively high and

the infiltration rates lower than on the comparatively gentle slopes or flat plains. Thus, while the increase in velocity has the potential to dislodge and carry away soil, the buildup of surface runoff on long slopes has the comparable ability in increasing erosion hazard.

Close observation of lands under use shows that rill erosion, in general, seemed to be associated with reduced ground cover resulting from cultivation. It is the most widespread and advanced form of visible erosion evident in the study area. Similarly, most rills are initiated from the farm floor, then cutting into the outer farm. The rills are more numerous and wider on the mid-slope and flatland farms.

Simple soil conservation measures such as planting cover crops, stubbles mulching, trash farming, minimum tillage, strip cropping (terracing), stone and soil bunds and *vertiver* hedgerow planting have been adopted by farmers to check soil erosion in the region, and the application of organic and inorganic fertilizer to improve the fertility of the soil. However, the growing population of the area is threatening the workability and sustainability of these measures. Better and more soil conservation measures are required to ameliorate soil degradation in the region.

4.7 Vegetation

The study region falls within the northern guinea savanna belt of the Nigeria's vegetation, which covers about 600,252 km², representing about 60% of the country's total land area (Odjugo, 2010; Salzmann *et al.*, 2002). Nigeria has a total land area of 923,769 square kilometers, out of which 86% (794,441 km²) belongs to the savanna region (Kundiri *et al.*, 1997). The Savanna region is sub-divided into four broad ecological zones, namely: Derived savanna, Guinea savanna, and Sudan and Sahel

savannas. The Guinea savanna was further subdivided into the southern Guinea savanna and northern Guinea savanna of Nigeria.

The vegetation of the study region is made up of grasses, aquatic and dry land weeds interspersed with shrubs and plants. The grasses and weeds consist of *Myparrhemia violescens* spp, *Penisetum pedicellatum*, *Schizachyrium exile*, *Typha*, wind sorghum, *Calotropis proceras*, and *Ipomeas* spp. This collectively makes up about 70% of the vegetation and their height ranges from a few centimeters to one meter tall. They are thick and fairly tall along the valleys and foothills of the mountains, but scattered, scanty and short along the slopes. The woody plants are made up of indigenous and exotic plants. The indigenous plants include *Vitellaria paradoxa*, *Tamarindys indica*, *Parkia species*, *Aegyptiaca* and *Balantie species* which are widely distributed and are found all over the region. *Neem*, *Eucalyptus*, *Mahogany*, *Date palm*, *Cashew*, *Mango*, and *Guava*, are some of the exotic plants found around settlements, forest and grazing reserves and plantations.

The vegetation of the study region is influenced by the regions' relief pattern, soils, and climate. The mean annual rainfall of about 1300mm to 1500mm, the shallow, stony, well drained and moderately fertile soils as well as the rocky and sloppy isolated hills and narrow valleys cause the region to have a variety of plant species. The vegetation resources of this region, in the various species, play very important roles in the man environmental relationship and harmony. They preserved the natural gifts, provide habitat and food for man and animals, protect the soil by covering it and provide fuel wood and timber for human use.

4.8 Population

Population is a very important factor in the man-environment relationship and socio-economic development of any region. Population characteristics such as size, growth rate, spatial distribution, demographic structure, literacy level, sex composition etc. are very crucial in the developmental processes and man-environment relation.

The study region is the third most populated regions in Taraba state, with a population of 958,700 people in 2015, and a density of 57.3 people per square kilometer (Table 4.3) (NPC, 2016). The state average population density is 65 per square kilometer. The concentration of people in the region might be due to physical as well as historical factors. Physical factors such as favourable climate and soil conditions contributed to successful agricultural activities in the region. The hilly nature of the region provides a defense during wars in the past and the location of Jalingo as both the local government and state headquarters of Taraba state attracted people.

The population is not evenly distributed. Zing and Yororo Local Government areas have the highest concentrations of 161.8 and 91.9 persons per square kilometer respectively, while Karim Lamido Local Government areas have the lowest with only 38.2 persons per square kilometer. The disparity in the density, however, is in relation to the land area difference. While Zing and Yororo have 1,029.83 and 1,275.58 km², Karim Lamido has 6,620.33km².

There is a disparity between males and females, in excess of about 2000 males. This may be attributed to migration, as migration is sex-selective involving more males than females. The population of the area is composed of 49% children with ages below 15 years and general literacy level below 50%. This is due to the scarcity of educational institutions, poverty and other social problems of the area. In ten years, the population

of the area has grown from 734,766 to 958,700 persons, at the annual growth rate of 3% (TADP, 2014). These population characteristics of the region place pressure on the soil resource based and socio-economic development of the area.

Table 4.3: Population, landmass, and population density of the study region
(Nigerian National Population Commission, 2016)

S/N	LGA	2015 Projected population	Land area (km ²)	2015 Population Density
1	Ardo Kola	114,538	2, 261.95	50.6
2	Jalingo	183,083	3,870.22	47.3
3	Karim Lamido	253,026	6,620.33	38.2
4	Lau	124,201	1,660.10	74.8
5	Yorro	117,253	1,275.58	91.9
6	Zing	166,599	1,029.83	161.8
	Total	958,700	16,718	464.6
	Study Region			57.3

4.9 Economic Activities

As rural dwellers, the primary economic activities of the people are farming. About eighty-five percent of the people are farmers while; only an estimated fifteen percent are engaged in other economic activities such as livestock husbandry and other natural resource extraction such as fuel wood harvesting, hunting etc (TADP, 2014; Taraba State Government, 2013).

4.9.1 Agriculture

As far back as the early 1970s, it was estimated that of the total land area in the research region, about 68.4% were classified as suitable for crop cultivation, and 10.5%

devoted to rangeland, while, degraded areas, bare rock surfaces, and natural forest made up the remaining 21.1%. Also, crop production was practiced only on the cultivable lands of the study region and is made possible by the existence of richly fertile farmlands and favorable climatic conditions.

Though the proportion stands unchanged, these percentages of land use have been altered considerably in recent times. There are now frequent cases of vertical spread of farmlands extending from valleys to upland areas and clashes between farmers and grazers either because animals have strayed into farm or farmers have extended their cultivation onto animal tracks, suggesting, therefore, a shift in land cultivation from the earlier topographical based land-use zonation. These increase intensification and integration of land use in recent times are made possible due to lack of adequate sustainable development management policies that will prevent the wrong choice and bad cultivation practices that may arrest the menace of soil erosion in the study region.

However, the economic future of the region is still very bright and depends largely on the success of formulating adequate, sustainable development policies, that will not only prevent the wrong choice and bad cultivation practices, but, also adequate supplies of agricultural inputs such as loans, fertilizer, seedlings, new breeds and farm machines. Also are adequate infrastructures such as irrigation schemes, marketing facilities, and road network among others. If these are done successfully, the region will be self-sufficient in food and manufacturing industries may spring up. Thus, the development of the vibrant economic potential of the study region has not been fully realized and until considerable efforts are put in place the promising economic possibilities of the region cannot be maximally reaped.

The life rhythm of agriculture alternates between a rainy season- a period of intense agricultural activities and a dry season- a period when some of the crops are harvested. Farming is the economic mainstay of the people of the area.

The agricultural system is typically one of subsistence; where mixed cropping and livestock farming system is the practice. Farm sizes vary with location, reflecting population density, accessibility to the farm and the personal preferences of the occupants (Yusuf & Ray, 2011). The most common crops cultivated in this region can broadly be classified based on their life cycle (that is, annual, biennial and perennial crops) or use, in which case we have four major groups including cereals, tubers vegetables and fruits.

4.9.1.1 Cereals

Guinea corn and maize is the principal crops widely cultivated in the study area. They are planted with the first rain mostly in April/May and harvested in November and December. The land is ridged up by hand and ex-drawn plows in the mountainous areas mostly and the crops planted in very close rows. My knowledge of the study region as an indigene and my interactions with the farmers in the month of July to September of the 2014 farming season indicates that the local guinea corn seeds have been in use for the past 99 years. The seeds being selected from the previous years' crop without any successfully introduced varieties. However, maize, which was introduced in the form of hybrid, has not captured the interest of the local farmers because of the numerous problems associated with its production. In addition, there seems to be no full awareness among the local farmers on the new hybrid and little or no incentives are given to farmers to encourage them. Wrong or inappropriate choice of land use site for cultivation is the major factor contributing to the problem of crop production generally.

This is because; the nature of the slope increasingly cultivated by farmers in recent times does not permit free use of farm machinery like tractors and combined harvesters.

The combination of these factors most often poses untold hardships to the inhabitants. This is because the cereals produced in the study region now seem to be grossly inadequate to the general inhabitants. For instance, information gathered during the field survey indicated that a 100kg, bag of guinea corn and maize, during the 2013/2014 cropping season was sold at over N8, 000.00 and N7, 500.00 (USD47 and USD44) respectively, (N170 = 1 US dollar). Most of which were even being imported from the central zone of the state. This is quite disturbing when compared with situations in the immediate central zone areas that were formerly totally dependent on the study region for food importation, where the same material cost between four and four thousand five hundred naira only (USD21.53 and USD29.41). Maize and Guinea corn are rooted on pieces of lands with root crops and leguminous crops.

4.9.1.2 Tubers

Yam and cassava are the main sources of carbohydrate and great importance in the food economy of the people of the study region. The estimated average annual production of the main agricultural crops in the study region shows that the highest yields (in metric tons per hectare) are obtained from yam and cassava, while the greatest tonnage is of yam, guinea corn, maize, and cassava.

Of the seven different varieties of yam known, the commonest ones grown in the study area are the white and yellow species, with their scales of production varying from one locality or tribe to another depending on their (locality's or tribal) taste. About 70% of the area under yam production has either vegetables or maize as a companion crop. A small piece of land is usually kept apart for cassava, which is inserted in the

rotation from time to time. Both yams and cassava are processed and used in preparing local dishes known locally as *tuwo*. The sweet cassava varieties and yam are boiled or roasted fresh for human consumption. A greater proportion of the cassava is also used in preparing *garri* and most often with the excess yams sold.

4.9.1.3 Vegetables

The principal vegetable cultivated in the study area includes okoro (*Abeimoscos esculeata*), pepper (*Capsicum spp*), tomatoes (*Lycopericon esculenta*), pumpkin (*Cucuibita spp*), garden eggs and wide varieties of green leaves including sorrel, and *amarantus*. Generally, the vegetables are mostly cultivated in small scale in the vicinity of the dwellings and houses by several farmers. Few of these crops are raised in the gardens in most cases in the dry season; largely for commercial purposes (for instance they are commonly seen at Zing and its environs). The crops are basically used locally in preparing soups while few of them especially garden eggs can be eaten raw.

Other crops include millet, rice, cassava, potatoes, groundnut, and beans. Local farmers were reluctant in engaging in their mass production, probably because of their low marketability at the moment, lack of improved seeds, the problem of continuous depletion of the fertility of farmlands and farmers inability to adopt new farming techniques as advised by extension agents.

Plowing of the fields commenced with the first rains. The plowing frequency varied with sites and crop types. In the highland areas plowing of field's starts before the first rains and repeated Plowing was done before sowing. This was because the farmers believe that it controls weeds, and crop yield will be better. The yam fields in the highland areas were plowed three to four times while; on the contrary, in the lowland yam fields were plowed only once or twice. For other crops, the fields were plowed

only once. Though, these plowings create a very rough surface, which provides a large storage space for the rainwater by that contributing to protecting the soil from erosion. Yet, as the amount of the rain and raindrop size increases, the roughness decrease over time, and surface runoff impacts trigger erosion. Farming operations are generally labor-intensive and largely a reflection of traditional methods, using drudgery-enhancing primitive tools such as hoes, cutlasses, machetes, and axes, which have been passed from generation to generation (Yusuf & Ray, 2011).

Keeping of large ruminants such as cattle and maintained through transhumance is the practiced in this region. Although the herds are comparably small and are kept as subsidiary activities, livestock husbandry in this area is predominantly extensive. The herdsmen have to move their herds in and out of the region on seasonal bases to keep with the cropping season and to look for good pasture in favourable locations during the dry season. The herdsmen and the farmers complement each other through the dropping of cow dung by the cows on their farms, after harvesting, which provide organic manure on the farms. The farmers, in turn, allow the cows to feed on the crop residues on their farms. This complementary coexistence of nomads and farmers in this region has some significance in the agricultural land management in the area. Even though, the sizes and numbers of the herds are few, they farmers and the herdsmen devise the ways of maximum utilization of the farms and herds resources.

Another subsidiary economic activity of the people of the region is fuel wood harvesting. The high demand for fuel wood in the urban areas due to scarcity and the high cost of fuel in the region has made the activity lucrative. On daily basis tons of firewood are offloaded from the many trucks to be sold for fuel. These fuel woods are brought from far and near the towns and trees are cut down indiscriminately leading to the perturbation of the vegetation. Thus, the growth of these crops, fuel wood

harvesting, and the rearing of these animals has threatened the natural resilience of the vegetation and soils of the region and, hence, has produced erosion.

Fishing is another primary activity in the region. River Benue provides sufficient opportunities for fishery activities in the region; Fishery and fish smoking activities are the principal occupations engaging a substantial number of people, especially in Karimlamido, Lau and Ardo kola local government areas. Other important primary activities in the area include pottery; mat making, and black smiting. The region also has a growing number of those who engaged in white-collar jobs owing to the assumption of a cosmopolitan character of Jalingo as the state capital.

4.9.2 Soil conservation

Despite, the fact that the farmers use traditional implements and system of agricultural production and have small land holdings, they do not only produce enough for consumption but also sell the surplus. This might be as a result of good land management and traditional agricultural system. The agricultural production systems that have been identified in the area are terrace farming, sedentary cultivation, and mixed farming. The farmers practice terrace to fight soil erosion.

The major soil conservation practices undertaken by the farmers in the study region are stone and soil bunds known locally as “*Kunya*” and “*Lambatu*” that were meant for water erosion control, and the application of organic and inorganic fertilizer to improve the fertility of the soil.

Some farmers with continuous cultivation maintain the land through intensive application of organic and chemical fertilizer to retain soil fertility. The farmers practice mixed farming where livestock such as sheep, goats, and poultry are kept to supplement the crop produce and to provide manure for the farms. The farmers also use the mixed

cropping system with compatible crops to prevent soil erosion, reduce the risk of crop failure in case of cultivating a single crop and to act as mulching to prevent soil desiccation. The differences between the highland and flatland areas in terms of soil conservation practices were negligible.

4.10 The People and culture

The study area is a highly heterogeneous and multiethnic region. The Ethnography of the study region is comprised of over thirty indigenous ethnic groups speaking different languages. Some of the major tribes include Mumuye, Wurkum, Yandang, Fulani, Jenjo, Kunini, Bandawa, Munga, Zo, and Bambuka, with each forming a mosaic in at least one local government area. Others registering a presence include the Bollere, Kode, and Lo, while some other tribes are too small numerically. The hausa language is commonly spoken by most indigenes of the study area irrespective of ethnic grouping. Other ethnic groups like the Yoruba and the Igbo are also found in a small number of most local government areas headquarters in the region (Yusuf & Ray, 2011).

Ethnography provides the cultural context within which the environment is understood and utilized for farming, fishing, and grazing. These are however manifested in their general behavior, social values, fashion, art and craft, dances, songs and musical instruments. Consequently, the region is richly endowed with a vast array of cultural festivals found amongst the different ethnic groups that make up the region. These festivals are celebrated on occasions ranging from death, birth, farming seasons, initiation into manhood or womanhood, installation of rulers, marriage, and general entertainment. Prominent among the major cultural festivals are the Sharo of the Fulanis in Jalingo, Ardo-Kola and, Lau Local Government Areas, and Mantau and NseNse festivals of the Mumuye people in Yorro and Zing Local Government Areas. Traditional dances performed by the people include Nyawata in Ardo-Kola, Jalingo, and

Lau, Local Government Areas. Moreover, the Tsakekke cloth (a hand-woven and dyed dress) worn by both men and women during festivals is an important part of the Fulani's culture in the area.

University of Malaya

CHAPTER 5: RESULTS

5.1 Introduction

This chapter presents the results and the analysis of data obtained from the administration of questionnaires. The data are mostly presented using frequencies converted to percentages.

5.2 Farmers' perception of soil erosion

This section presents and interprets the results in four successive headings. The first addresses some personal and demographic characteristics of farmers and their land ownership. The second covers farmers' perceptions of soil erosion and their preferences for cultivating hill slopes in the study region. The third appraises farmers' perceptions of the factors associated with soil erosion problem and its indicators, effects and consequences. The last covers farmers' perceptions of the trend of water erosion over the last ten years in the research region.

5.3 Socio-economic characteristics of farmers and frequency of responses

The socio-economic variables discussed in this section include farmers' age, sex, marital status, educational level, household size and income level. Others are the farmers' methods of farmland acquisition, farm size, farm distances and a number of plots (s), worked per farmer as well as the farmers' farming experiences.

5.3.1 Age distribution of farmers

Age classification is relevant to this study in that physical ability, productivity and agility depend on age. Moreover, the predisposition or susceptibility of farmers to erosion control is determined by age. Table 5.1 below shows the age distribution of farmers in the study region.

Table 5.1: The age group distribution of farmers

Age group (Year).	Frequency of Responses	% Responses
Young (17- 35)	122	31.9
Middle (>35-50)	220	57.4
Old (>50)	41	10.7
Total	383	100

A careful observation of table 5.1, reveals that about 31.9% of the sampled farmers are young in the age bracket of 17-35 years; the majority 57.4% fell in the middle age category > 35-50 years, while, 10.7% were in the older age category 50 years and above. This means that greater percentages of the farmers (57.4%) in the research region were mainly middle-aged >35-50 years (figure 5.1). This suggests the farmers are still in their economically active stage of age. Hence, the likelihood of adoption of soil conservation measures in the study region. This is because; farmers of middle-aged generally, influence many farming activities, especially in terms of increased hectares of farmlands and improved conservation practices. Moreover, the peasant farmers of middle-aged are more enthusiastic and have more physical vigor and family responsibilities than the young and old farmers.

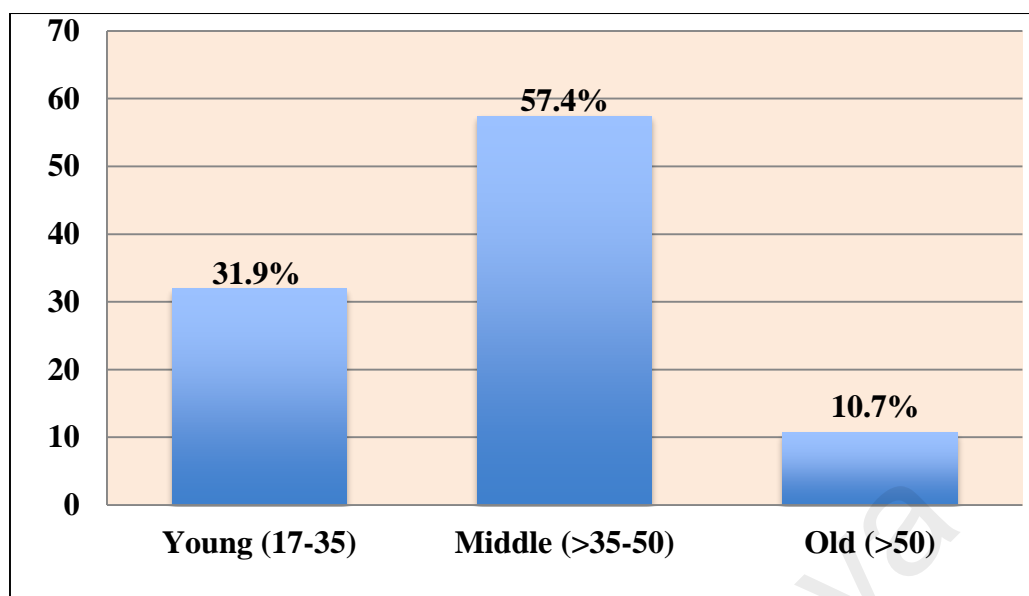


Figure 5.1: Farmers' age group distribution

5.3.2 Sex distribution of farmers

Gender is an important social factor that influences the kind of profession an individual undertake. Some professions are referred to as male dominant while others are said to be female dominated, especially, in the African traditional society. Table 5.2 shows the percentage of farmers' responses and their sex distribution in the study region with respect to farming.

Table 5.2: Sex distributions of farmers

Sex	Frequency of Responses	% Responses
Male	338	88.3
Female	45	11.7
Total	383	100

From table 5.2, the result indicates that the majority of the farmers interviewed 88.3% were male, while, 11.7% were female. This means that greater percentages of the

farmers in the research region are male. Conditions that suggest gender discrimination with respect to agriculture, and farming activities are male dominated in the study region. However, the smaller percentage of female farmers sampled is reflective of the fact that women in general, and in the study region in particular depend on their husbands for a livelihood. The women rarely claim ownership of farms and usually regard their husbands as the owners of the family farms.

5.3.3 Marital status

In the African traditional society, marriage means a sense of responsibility, meaning that the farmers have the responsibilities of catering for their families. This implies that much farming activities, especially in terms of increases hectares of cultivated farmland, and the practice of soil conservation measures might be expected. Table 5.3 bellow shows the percentage of farmers' responses and their marital status in the study region.

Table 5.3: Farmers' marital status

Status	Frequency of Responses	% Responses
Unmarried	7	1.8
Married	348	90.9
Divorced/ Widower	28	7.3
Total	383	100

From table 5.3, it can be seen that 90.9% of the sampled farmers are married, while, only 7.3% and 1.8% were divorced/widowed and unmarried respectively. This means that greater proportions of the farmers in the research region are married. The greater percentage of married farmers in the research region suggests that family responsibility

or consumption might increase. Hence, increased in the intensity of use of land and improved conservation measures might be expected.

5.3.4 Educational status of farmers

Despite the expected role of accumulated years of farming experiences, which enhances farmers' deeper knowledge of their fields and the knowledge handed down to them by the ancestors. Yet, the level of educational attainment remains paramount in enhancing farmer's understanding of soil erosion and the practice of soil conservation measures. Thus, literate farmers tend to have a better understanding of the risks associated with soil erosion and tend to spend more time and money on soil conservation measures than the not-literates farmers. Table 5.4 shows the percentage of farmers' responses with respect to their educational attainment, in the study region.

Table 5.4: Educational levels of respondents

Educational level	Frequency of Responses	% Responses
Non-formal education	154	40.2
Primary school	121	31.6
Secondary school	64	16.7
Post-secondary school	44	11.5
Total	383	100

From table 5.4 the results indicate that about 40.2% of the respondents are without formal education; the majority 59.8% of the respondents has acquired formal education. Among those, the majority forming 31.6%, and 16.7%, had a primary and secondary education respectively (figure 5.2). These means that the greatest percentage of farmers sampled are literate. The low proportion of illiterates in the respondent's groups implies

that the majority of them are in a better position to be aware or understand soil erosion and practice soil conservation measures.

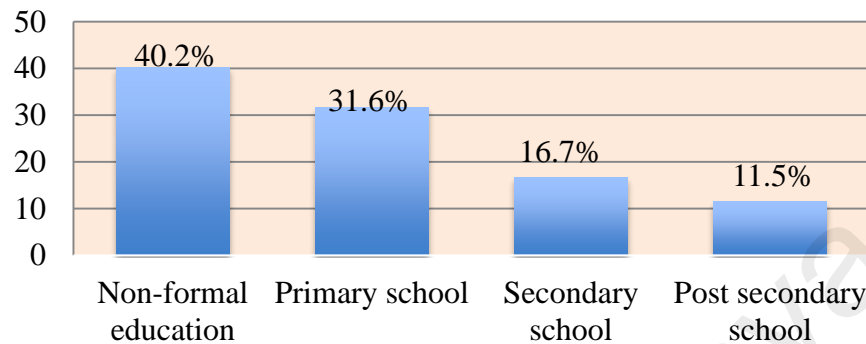


Figure 5.2: Educational levels of respondents

5.3.5 Household size

In the African society, household size plays a significant role in the socio-economic status of a farmer. The level of production and productivity of small-scale farmers are determined by the size of the household and its composition. When the majority of the household members are in an agricultural productive class (between 15 and 60 years old), they might positively influence the practices of soil conservation. This is because effective soil conservation practices are optimistically ties to the high labour force in the households. On the other hand, where the households' size is larger with many mouths to eat rather than to work, they might negatively influence the level of production and productivity of small-scale farmers. Thus, farmer's response to soil erosion is influenced by the demand of family members. Table 5.5 shows the percentage of farmers' responses with respect to their household size in the research region.

Table 5.5: Household size of the sample respondents

Size	Frequency of Responses	% Responses
1 - 4	59	15.4
5 - 8	151	39.4
9 -12	125	32.6
>12	44	12.5
Total	383	100

From table 5.5, the study revealed that a greater percentage of the respondents could be said to have a large household size of 5 members and above. The table puts the figure of households that can be described as large at over 84%, while 1-4 members at 15.4%. The relatively large household sizes suggest that the farmers might use family labour, to reduce labour cost required in soil conservation practices. Hence, the practice of measures to combat soil erosion menace and fertility depletion might be expected.

5.3.6 Farmers' income

High agricultural economic efficiency increases households' enthusiasm for soil erosion and conservation investments, in addition to their perceptions and attitude. Hence, households with higher income are more likely to understand soil erosion processes and implement effective conservation measures in their fields than farmers with low income. Table 5.6 shows the income farmers derive from farming in the study region.

Table 5.6: The income distribution of farmers

Income in Naira (N)	Frequency of Responses	% Responses
N 1,000- 30,000	196	51.2
N 31,000 – 60,000	148	38.6
N 61, 000 – 90,000	35	9.1
N91, 000 – 120,000	4	1.1
>120,000	0	0
Total	383	100

It can be seen from table 5.6 that, the majority of the respondents forming 51.2% earned below N 30,000 as income from their farm proceeds annually. A relatively small proportion 38.6% and 9.1%, earned between N31, 000-N60, 000 and N61, 000-N90, 000 respectively. While 1.1% earned between N91, 000 to N120, 000, but none earned up to N121, 000 and above annually. This means that majority of the farmers in the research region has low income from their farm proceeds annually. This implies that the farmers' ability to appreciate and practice soil conservation measures for the control of soil erosion and soil fertility amendments is less likely to be viable.

5.3.7 Landownership

Secured landholding provides farmers with incentives, including transferring land possession to their children and as collateral. It also encourages farmers to effectively plan and implement relatively permanent soil conservation structures on their farms. Moreover, insecure landholdings invariably dissuade farmers' motivation to apply soil conservation measures, because they may not themselves be able to reap the benefits. Table 5.7 below shows the percentage of farmers with respect to their land ownership in the study region.

Table 5.7: Ownership of farmland by farmers in the study region

Ownership of Farmland	Frequency of Responses	% Responses
Yes	379	99.0
No	4	1.0
Total	383	100

From table 5.7, the findings indicate that almost all the respondents forming 99% owned their land holdings. This means that the majority of the farmers in the study region own their landholdings. This finding with respect to land ownership in the study region suggests that, the farmers' efficiency and potentials of practicing measures for water erosion and fertility depletion might be enhanced.

5.3.8 The influence of land ownership on soil erosion

This is about how farmers in the study region acquired their farmlands. Table 5.8 shows the percentage, which was worked out, based on the frequency of occurrence of each method.

Table 5.8: Methods of ownership of farmland by farmers in the study region

Methods ownership of farmlands	Frequency of Responses	% Responses
Inheritance	375	97.9
Lease	2	.5
Purchase	6	1.6
Total	383	100

It is evident from table 5.8, that inheritance 97.9% has the highest percentage, while only 1.6% and 0.5%, of the respondents, had mentioned purchase and lease respectively

as other methods of acquiring land in the research region. This means that the greater percentage of farmers in the research region acquired their land through inheritance. This could not be unconnected with the fact that traditionally land ownership in this region is basically communal. The land is passed down to the children, both from father and uncle through inheritance procedures.

5.3.9 Farmers' farmland size

Land use and the practice of measures for soil erosion by water and soil fertility depletion have a strong positive or negative association with farmers' farmland sizes. Farmers with larger holdings are more likely to practice lumpy measures for erosion control and soil fertility amendment than those with smaller holdings because adoption costs relative to farm size are lower. Table 5.9 shows the percentage of individual farm sizes of the farmers in the study region.

Table 5.9: Farmers' farmland size

Farm size (Ha)	Frequency of Responses	% Responses
< 1 ha	215	56.1
1-2 ha	154	40.2
2.1-3 ha	13	3.4
3.1-4 ha	1	.3
Total	383	100

From table 5.9, the findings reveal that the majority of the farmers forming 96.3% have relatively small farm sizes of less than 2.1 hectares. Within this proportion, the majority 56.1% has less than 1 hectare, while, 40.2% less than 2.1 hectares. Only 3.4% and 0.3% of the farmers had 2.1-3 and 3.1-4 hectares respectively. This means that individual farm sizes in the research region are small. This small farm size indicates

that, 1. The respondents were basically peasant farmers operating on small farm sizes, and 2. The likelihood of adoption of lumpy measures for erosion control and soil fertility enhancement might be slighter. The reason for this small farmland sizes could be related to the ownership of land in the area, which is communal and leads to land fragmentation through an effort to allocate land to every heir of the family. In addition, to the farm sites, most of which are located on hill slopes and farmers have to work hard to locate spaces where the soil is deep.

5.3.10 Number of farm plots worked per farmer

The number of farm plots worked by individual farmers influences to a very great extent their practice of measures for halting soil erosion and depletion of soil fertility. Furthermore, the type of soil conservation practices employed by farmers depends on the time needed to work on each farm and the farm's topographical location relative to numbers of farms cultivated. Table 5.10 shows the number of farm plots worked by each farmer in the research region.

Table 5.10: Distribution of respondents according to the number of farm plots worked by them

Number of farm plots	Frequency of Responses	% Responses
1 - 4	79	22.7
5 – 8	178	46.5
9 – 12	89	23.2
>12	29	7.6
Total	383	100

It can be seen from table 5.10 that, the numbers of plots, farmers in the study region cultivate range from 1 to 12 and above. The majority forming 46.5%, however, worked

on between 5 to 8 plots, 23.2% worked on 9 to 12 farm plots, while, only 22.7% worked on 1 to 4 plots. This means that the majority of the respondents 77.3% worked on more than 5 farm-plots. Thus, a condition that suggests, the farmers' ability to practice efficient measures for halting soil erosion by water and improving the fertility of soil might be negatively impacted.

5.3.11 Farm distances

Farm distance is one of the major factors, which influenced the small-scale farmers' level of production and productivity particularly, in the African traditional society. For optimum and regular observations and the practices of sustainable soil conservation measures, distance to farm fields from the homestead is expected to be shorter. Thus, table 5.11 shows the farm distances walked by each farmer in the research region.

Table 5.11: Respondents' farm distance (km)

Distance in km	Frequency of Responses	% Responses
Less than 1	1	.3
1- 3	173	45.2
3.1 - 6	187	48.8
6.1- 9	22	5.7
Total	383	100

From table 5.11, the majority of the respondents 48.8% and 45.2% indicated that their cultivated fields were located between 3.1 to 6 km, and 1 to 3km from their residences respectively. While 5.7% of the respondents have to work a distance of over 9km from their homesteads and only 0.3% of the respondent showed that their farm fields exist close to homestead (less than 1km). This entails that more than 54% of respondents have their farmlands located at a distance of more than 3km away from

their residences. This implies that farm distances in the research region exist far from the homestead, and thus, the likelihood of optimum and regular observations and the practices of sustainable soil conservation measure might remain limited.

5.3.12 Farmers' perception of farm distances

This is about how farmers in the study region perceived their farm distances from their homestead in the study region. Table 5.12 shows the percentage, which was worked out, based on the frequency of occurrence of each response.

Table 5.12: Respondents' perception of farm distance (km)

Distance in km	Frequency of Responses	% Responses
Near	18	4.7
Moderate	52	13.6
Far	163	42.6
Very far	150	39.2
Total	383	100

From table 5.12, it is evident that majority of the respondents 42.6% and 39.2%, perceived their farm distances from their residences as far and very far respectively. 13.6% as moderate and only 4.7 % of the respondents perceived as near. This implies that the greater percentage of farmers (81.8%) in the research region perceived farm distances to be either far or very far from their homestead. This suggests that farmers in the research region have a high perception of farm distances being far from their homestead. Hence, the level of production and productivity of the small-scale farmers might be impeded by the perceived farm's distances in the research region.

5.3.13 Farming experience

In the African traditional context, farming experience refers to a tool for acquiring and developing farmers' understanding of indigenous knowledge system and its uses in soil erosion and conservation measures. Farmers' perception of soil erosion and conservation measures is governed by past experiences. Hence, if standard measures of soil erosion and conservation measures are to enhance and properly implemented, the individuals' farming experiences needs to be understood especially in the African traditional system. Thus, Table 5.13 shows the percentage of farmers' responses with respect to their farming experiences in the study region.

Table 5.13: Respondents' farming experiences

Years	Frequency of Responses	% Responses
1-5	26	6.8
6-10	77	20.1
11-15	88	23.0
16 and above	192	50.1
Total	383	100

From table 5.13, the majority of the farmers 50.1% have been in the farming business for about 16 years and above, 23.0 % for 11-15years. Only 6.8% have farming experience of fewer than 5 years. This means that the majority of the farmers in the research region had a long period of farming experiences. A condition that suggests, farmers in the research region would have a better understanding of soil erosion and conversant with constraints and needs to increase conservation measures. Also, long years of farming experience upsurge the farmers' level of acceptance of new ideas as a means of overcoming their production constraints, and hence, increase production

5.4 Farmers' perception on soil erosion by water and their preferences for cultivating hillslopes areas

This section assesses the perception of farmers on soil erosion and their preferences for cultivating hill slopes in the study region

5.4.1 Farmers' perception and awareness of soil erosion by water

Farmers' perception of soil erosion is one of the significant social factors that determine the degree of understanding about soil erosion. However, such perceptions vary from one region or locality to the other depending on the prevailing ecological and socio-economic characteristic. Thus, table 5.14 shows the farmers' awareness of water erosion in the study region.

Table 5.14: Farmers' awareness of water erosion in the study region

Awareness	Frequency of Responses	% Responses
Aware	383	100
Not aware	0	0
Total	383	100

From table 5.14, the results showed that all the 100% sampled farmers are knowledgeable and aware of soil erosion by water. This implies that there is a high level of awareness among farmers of soil erosion by water in the research region. This implies that farmers' in the research region are much more likely to practice sustainable soil conservation measures to halt water erosion on their farms.

5.4.2 Farmers' perception of water erosion as a problem

This is about how farmers in the study region perceived soil erosion by water on each of their plots during the normal cropping year. Table 5.15 shows the farmers' perception of water erosion as a problem in the study region.

Table 5.15: Farmers' perception of water erosion as a problem in the study region

Perception	Frequency of Responses	% Responses
Yes	352	91.9
No	31	8.1
Total	383	100

From table 5.15, the findings revealed that 91.9% of the farmers constituting the majority perceived water erosion as a problem in their fields, while, the remaining 8.1 % exited ignorantly. This higher percentage of farmers that perceived water erosion as a problem implies that soil erosion by water is a problem constraining crop production in the research region. Thus, farmers' practice of different alternatives of soil conservation measures is expected.

5.4.3 Farmers' perception of the topography of the farmland

Soil erosion; the process by which soil is rendered less and less capable of achieving the medium of plant growth, occurs in various forms depending on land use sites, but the mountainous areas and sloppy fields, where agriculture is practiced are especially more prone to severe erosion hazards following excessive deforestation, faulty cultivation, and overgrazing. Hence, table 5.16 shows the location of the farmers' fields in terms of ground slope in the study region.

Table 5.16: Perception of slope gradient of cultivated plots owned by respondents

Slope category and gradient	Frequency of Responses	% Responses
Flat land < 4%	120	31.3
Gentle slope 4-8%	126	32.9
Steep slope 8-30%	137	35.8
Total	383	100

Findings indicated in table 5.16 revealed that the majority of the respondents forming 68.7% have their farmlands either located on the steep slope (35.8%), or gently slope (32.9), a place where most soil erosion is taking place (see figure 5.4). Only 31.3 % have their farms located on flatland area (figure 5.3). This implies that the majority of the farmers in the research region cultivates on the hill slope environment. A condition that indicates that, the research region could be more susceptible to severe water erosion hazard.

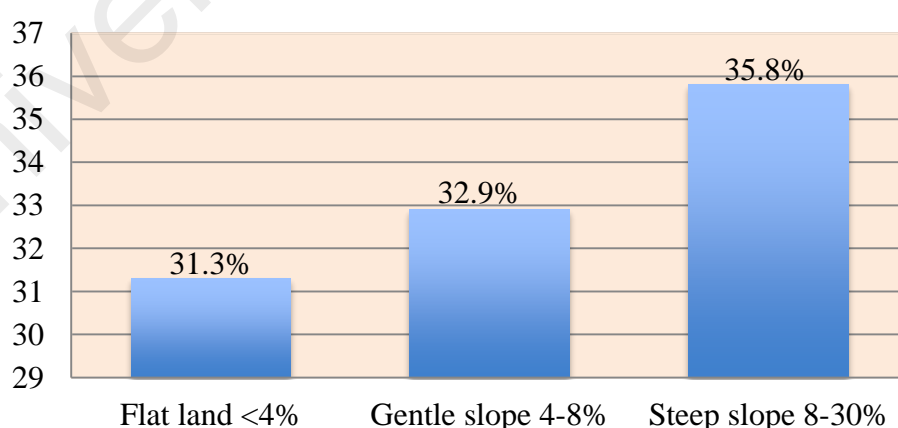


Figure 5.3: Slope gradient of cultivated plots owned by respondents



Figure 5.4: The slope gradient of the farmers' field in the study region

5.4.4 Farmers' preferences for using hill slope for agriculture

It is widely acknowledged that the conversion and intensification of agricultural activities in sites such as mountainous regions and sloppy lands accelerate soil erosion which in turn threatens valuable soil nutrients and creates serious soil management problems. Hence, table 5.17, shows the farmers' reasons for cultivating hill slopes in the study region.

Table 5.17: The reason why prefer to farm on the slope instead of flatland areas in the study area

Reasons	Frequency of Responses	% Responses
Less weed invasion	79	30.0
Historical reason	56	21.3
Less crops destruction by animals	116	44.1
Shortage of farmlands	8	3.0
Others	4	1.5
Total	263	100

**Hilltops have been refuges sites in the olden days against enemies*

From table 5.17 and figure 5.5, it can be seen that the majority of the farmers 30.3% cultivate hill slopes areas because of less crop destruction by animals, followed by less weeds invasion 20.6%. 14.6% mentioned the historical reason, while, 2.1 % of the respondents cultivate because of shortages of flatlands and others 1.0%. This means that the majority of the farmers forming 96.9% prefer to cultivate the hill slopes, not because of the shortages of flatland areas, but because of less crop destruction by animals, less weed invasion, and historical reasons. These results, therefore, give a clear picture of the level of perception of soil erosion in the research region as perceived by the respondents.

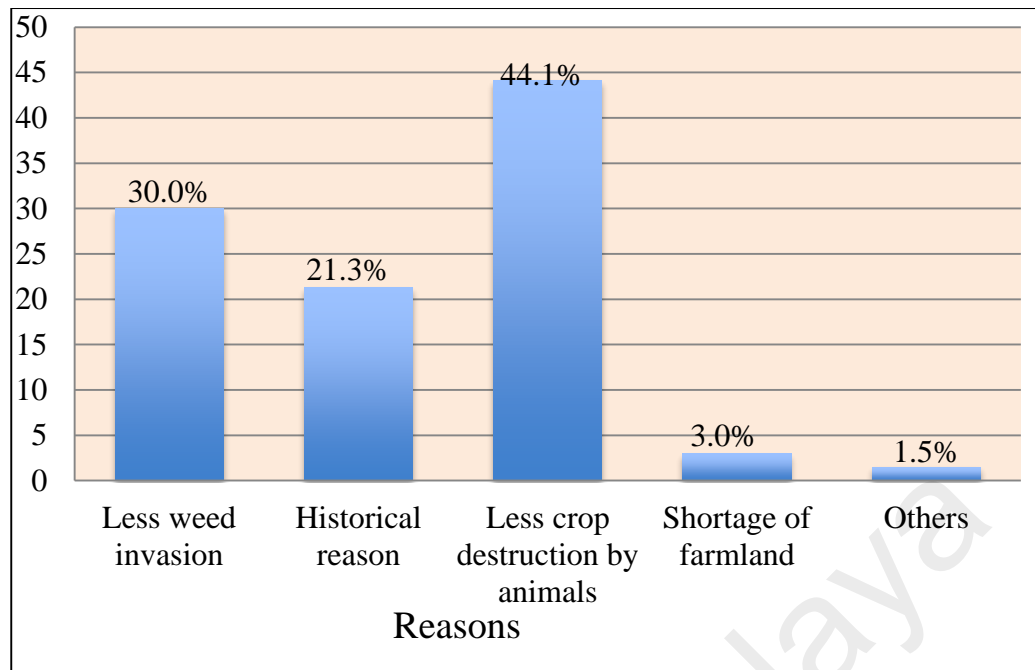


Figure 5.5: Why farmers' prefer to farm on a slope instead of flatland areas in the study region

5.4.5 Farmers' perception of crop yields

This is about how the percentage of farmers who cultivates on gentle and steep slopes perceived crop yields on hill slopes as compared to flatland farms.

Table 5.18: Farmers' perception of crop yields on slopes farmlands as compared to flatland farms

Crop better yielded on the slopes than flatland area	Frequency of Responses	% Responses
Yes	207	78.7
No	56	21.3
Total	263	100

It can be seen from table 5.18, that the majority of the farmers measuring 78.7% agreed that their crops are better yielded on the slopes than on flatlands farms, while

21.3% disagreed. This means that farmers in the research region have the high perception that crops are better yielded on the slopes than flatland site. Thus, a situation that suggests, the farmers' reason for cultivating the hill slopes whereas flatland areas exist.

5.4.6 Farmers' reasons for improved crop yields on slopes

It is widely acknowledged that land use sites influence crop yields differently. However, the extents to which land use sites influence crop yields vary with land use management and perception. Thus, Table 5.19 shows the percentage of farmers who cultivates on gentle and steep slope reasons for improved crop yields on slopes as compared to flatland farmlands.

Table 5.19: Farmers' reasons for improved crop yield on slopes compare to flatland areas

Reasons	Frequency of Responses	% Responses
Good farm management	114	43.3
Nature of the soil	91	34.6
Nature of the topography	38	14.4
Fertilizer application	20	7.6
Total	263	100

From table 5.19, it can be seen that the majority of the farmers forming 43.3% and 34.6% mentioned good farm management and the nature of the soil as main reasons for improved crop yield on the hill slope. A relatively small percentage of the respondents 14.4% reported nature of the topography, and fertilizer application 7.6%, was least perceived as the main reason. This implies that the majority of the farmers forming 77.9% perceived good farm management and nature of the soil as main reasons for

improved crop yield on the hill slope site. This could be the reason why farmers cultivate hill slopes in the research region.

5.5 Farmers' causes, indicators, effects, and consequences of soil erosion in the study region

This section explores farmers' perceptions of the factors associated with soil erosion problem, its indicators, effects, and consequences.

5.5.1 Causes of soil erosion as identified by farmers

This is about the farmers' perceived causes of soil erosion under agricultural lands in the study region. Table 5.20 shows the percentage of farmers' responses with respect to the causes of soil erosion on their individual farmlands.

Table 5.20: Farmers' perception of the causes of water erosion on their farmlands

Farmers' factors of soil erosion	Frequency of Responses	% Responses
Intensity of rainfall	145	37.9
Types of soil and erodibility	69	18.0
Slope steepness of cultivated farms	37	9.7
Insufficient and delayed fertilizer	51	13.3
Poor designed and delay of soil conservation	18	4.7
Careless cultivation	18	4.7
Increase pressure of human and bovine population	27	7.0
Others	18	4.7
Total	383	100

From table 5.20, it can be seen that the majority of the respondents 37.9%, 18.0% and 13.3% reported intensity of rainfall, types of soil and erodibility, insufficient and delayed fertilizer as the major cause of soil erosion. A significant proportion 9.7% chose slope steepness of cultivated farms. Other factors least mentioned by respondents in order of significance are increased pressure of human and bovine population 7.0%, careless cultivation 4.7%, and poor designed and delay of soil conservation 4.7% (figure 5.6). This means that the majority of the farmers in the research region 85.9% perceive natural and institutional factors as the main causes of soil erosion. This suggests, therefore, that the majority of the farmers in the research region do not see soil erosion as an individual problem on their own farms.

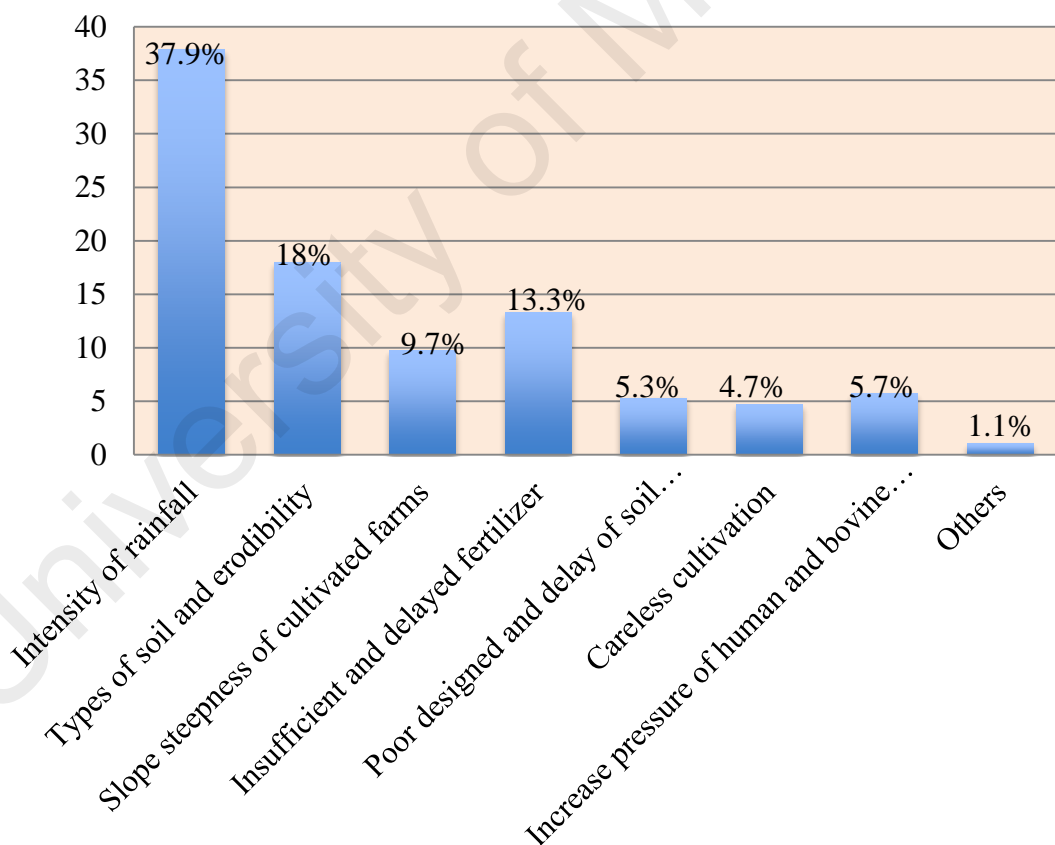


Figure 5.6: Major causes of soil erosion as identified by farmers

5.5.2 Respondents' period of cultivating farmlands

The length of time a piece of land is subjected to a type agricultural activity affects its resilience and rendered it more susceptible to erosion. In another word continue cultivation of the same piece of land over a long period of time renders the soil too loose, and susceptible to agents of erosion, this is particularly true of the tropical soils. Table 5.21 shows the period farmers in the study region started cultivating their farmlands.

Table 5.21: The period farmers in the study region started cultivating their farmlands

Time (Years)	Frequency of Responses	% Responses
1 – 3	33	8.6
4 – 6	46	12.0
7 – 10	61	15.9
10 – 12	94	24.5
Above 13	149	38.9
Total	383	100

From table 5.21, the finding indicates that the majority of the farmers 38.9% have been continuously cultivating their farmlands for the past 13 years and above, 24.5% and 15.9% for the past 10-12 and 7-10 years ago. While only 8.6% started cultivating their farmlands in the last 1-3 years. This means that the majority of the respondents measuring 79.3% have been cultivating the same piece of their land for the past 7 years and above. This implies that most agricultural fields in the research region are being subjected to continuous cultivations. Thus, in the absence of optimum measures for water erosion control, and soil fertility depletions, continuous cultivation might result in

loss of farms and fertility deterioration. Additionally, the resilience ability of the soils might be negatively impacted, and hence, more susceptible to agents of erosion.

5.5.3 Indicators of soil erosion on cultivated plots as identified by farmers

Perception is a process of information extraction by which people select, organized and interpret physical stimulation into a meaningful and coherent picture of the world. Thus, farmers' perceptions of water erosion in terms of the period of identification and the interpretation of its indicators is greatly influenced by the ways the individual farmers sees the soil through the information he receives from the soil. Such perception, however, does not only vary across culture through time, they also may differ among various ethnic groups within communities, regions, and cities. Thus, the prevailing situation in the research region is as presented in table 5.22 below.

Table 5.22: Farmers' methods of identifying soil erosion

Period and methods	Frequency of Responses	% Responses
When the root of plants began to expose	30	7.8
When there is drop in yield	53	13.8
When rill/gullies developed	184	48.8
When there is change in soil colour	81	21.1
When sheet erosion developed	7	1.8
Nearness of rock to the surface than before	26	6.8
Other	2	0.5
Total	383	100

From table 5.22 the result shows that the major indicators farmers mentioned are; when rill/gullies developed 48.8%, (see figure 5.8) and when there is a change in soil

colour 21.1%. A significant proportion of the farmers constituting 13.8% and 7.8 % mentioned when there is a drop in yield, and when the root of plants began to expose respectively (figure 5.7). While, the least mentioned indicators was nearness of rock to the surface than before 6.8%, and when sheet erosion developed 1.8%. This means that most farmers are aware that soil erosion in various forms is taking place on their farmlands. This is based on their perception and interpretation of all indicators that reveal certain conditions regarding soil erosion severity.

However, a careful observation of table 5.22 reveals that more than 86% of the sampled farmers observe for physical signs on their individual farmlands as the major indicators suggesting the severity of soil erosion on their farms.

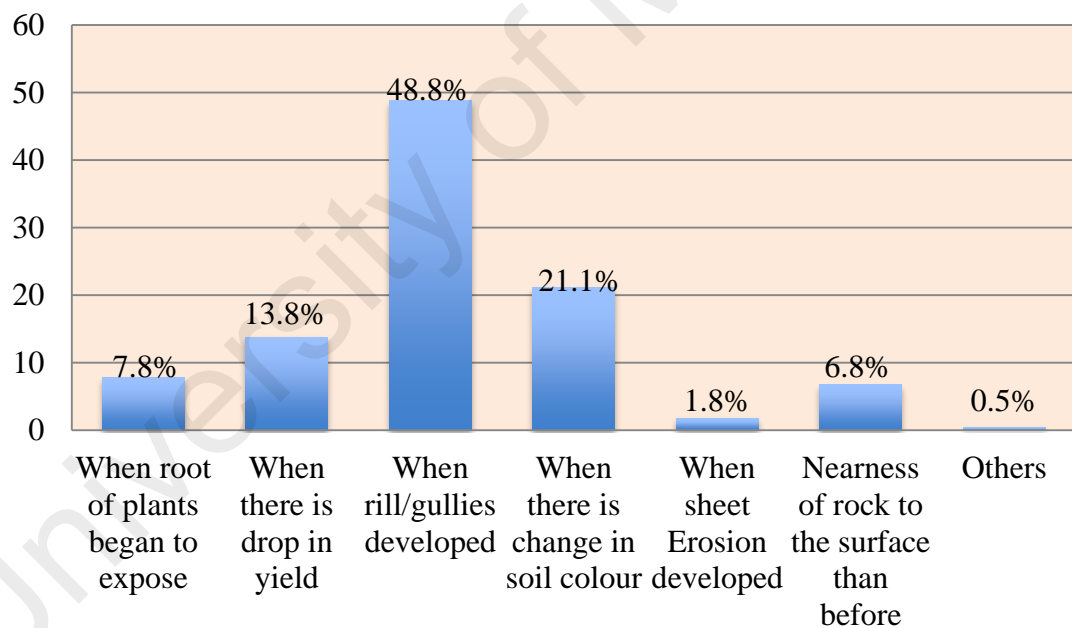


Figure 5.7: Farmers' period and methods of identifying soil erosion on their cultivated fields



Figure 5.8: Rill and gully erosion on cultivated plots observed at the hillslope in study region

5.5.4 The impact of soil erosion on cultivated plots as identified by farmers

The effects of soil erosion on the agricultural lands can simply be referred to as soil degradation (Figure 5.11). This means the lowering of the productive and other services/utility qualities of the entire landscape. The magnitudes vary over space and time and depend on the sensitivity and resilience nature of the soil as well as soil and crop management practices in use. Hence, farmers' perception of the effects of soil erosion do not only vary across culture through time, it also differs among various ethnic groups within communities, regions, and nations. This depends on a judgment between options that relate to the whole range of economic, cultural, and biological parameters. In this regard, table 5.23 shows the effects of soil erosion in the research region as identified by farmers.

Table 5.23: The impact of soil erosion on farmers' farmlands

Farmers' effects of soil erosion	Frequency of Responses	% Responses
Reduction of arable lands	211	55.1
Submerges of fertile arable lands	47	12.3
Blockage of irrigation channels	13	3.4
Require high input and management	58	15.1
Drop in yield	39	10.2
Reduction in fallow period	6	1.6
Loss in productivity of cropping lands	9	2.3
Total	263	100

From table 5.23 it can be seen that more than 55.0% of the sampled farmers indicated that their farmland sizes have been reduced by erosion, 15.1% and 10.2% mentioned that, their farms require high input and management, and drop in yield respectively. While about 12.3% reported that their cultivated fields were reduced in size by being submerged, and by a loss in productivity of cropping lands 2.3% (figure 5.9). This shows that all the farmers sampled are well aware of the effects of water erosion on their individual fields, and the majority perceived a reduction in farmland sizes as the major effect of water erosion on their individual farmlands.

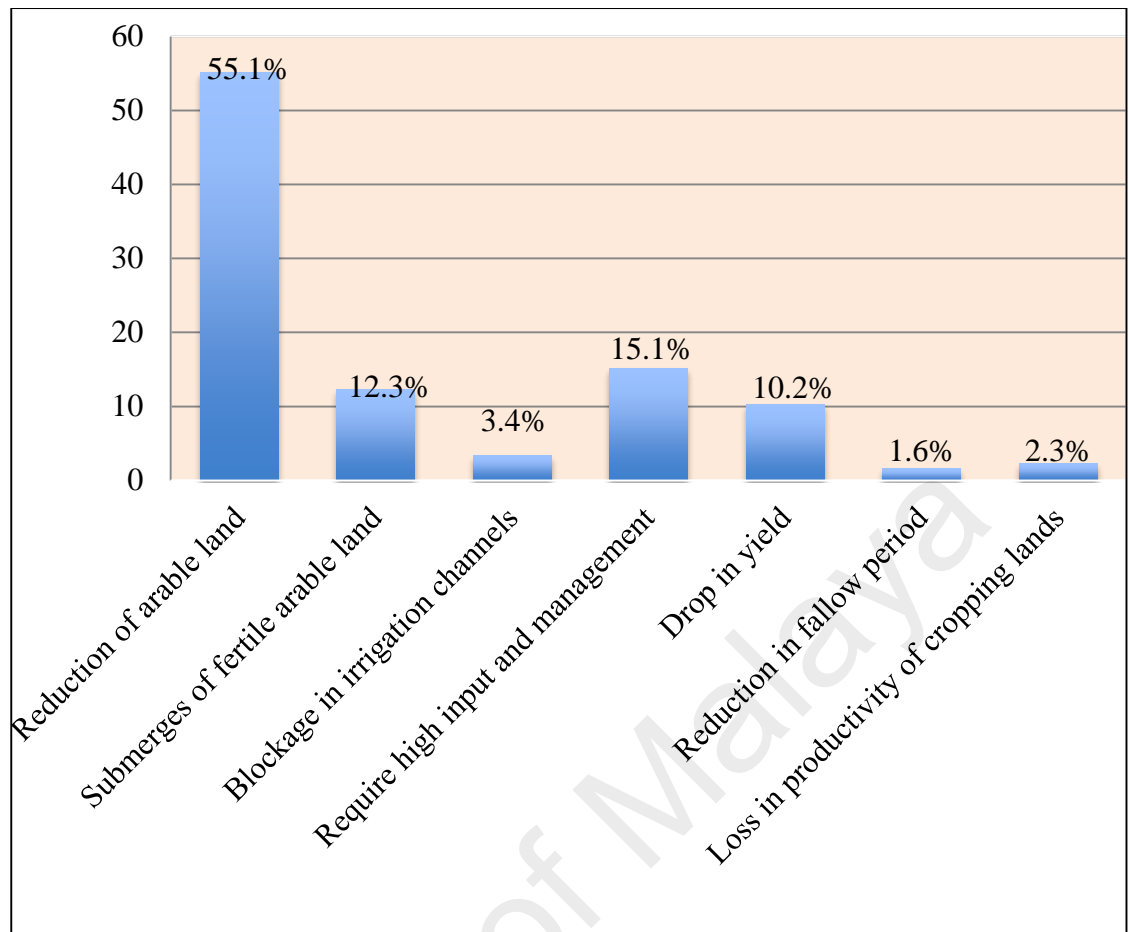


Figure 5.9: The impact of soil erosion in the research region as identified by farmers

5.5.5 Perception of the consequence of soil erosion

This is about the farmers; perceived consequences of soil erosion in the study region. Table 5.24 shows the consequences of soil erosion in the research region as identified by farmers.

Table 5.24: Farmers' perception of the consequences of soil erosion

Farmers' consequences of soil erosion	Frequency of Responses	% Responses
Led to low yields	106	27.7
Reduced grazing land for livestock	17	4.4
Food insecurity and poverty	110	28.7
Poor standard of living	84	21.9
Decrease in fuel wood availability	22	5.8
Migration of rural dwellers	34	8.9
Famine	10	2.6
Total	383	100

From table 5.24, it can be seen that majority of the farmers respectively, 28.7%, 27.7%, and 21.9% reported food insecurity and poverty, low yield, and low standard of living as the major consequences of soil erosion. A relatively smaller percent of the respondents mentioned migration of rural dwellers 8.9%, and a decrease in the availability of fuel wood 5.8% as the consequences of soil erosion (figure 5.10). While, reduced grazing land for livestock 4.4%, and famine 2.6%, was least perceived. This means that as a whole, the farmers in the research region have a high perception of the consequences of soil erosion, as is seen in their ability to perceive all the variables as consequences soil erosion. Suggesting, the likely practice of sustainable soil conservation measures on their farms.

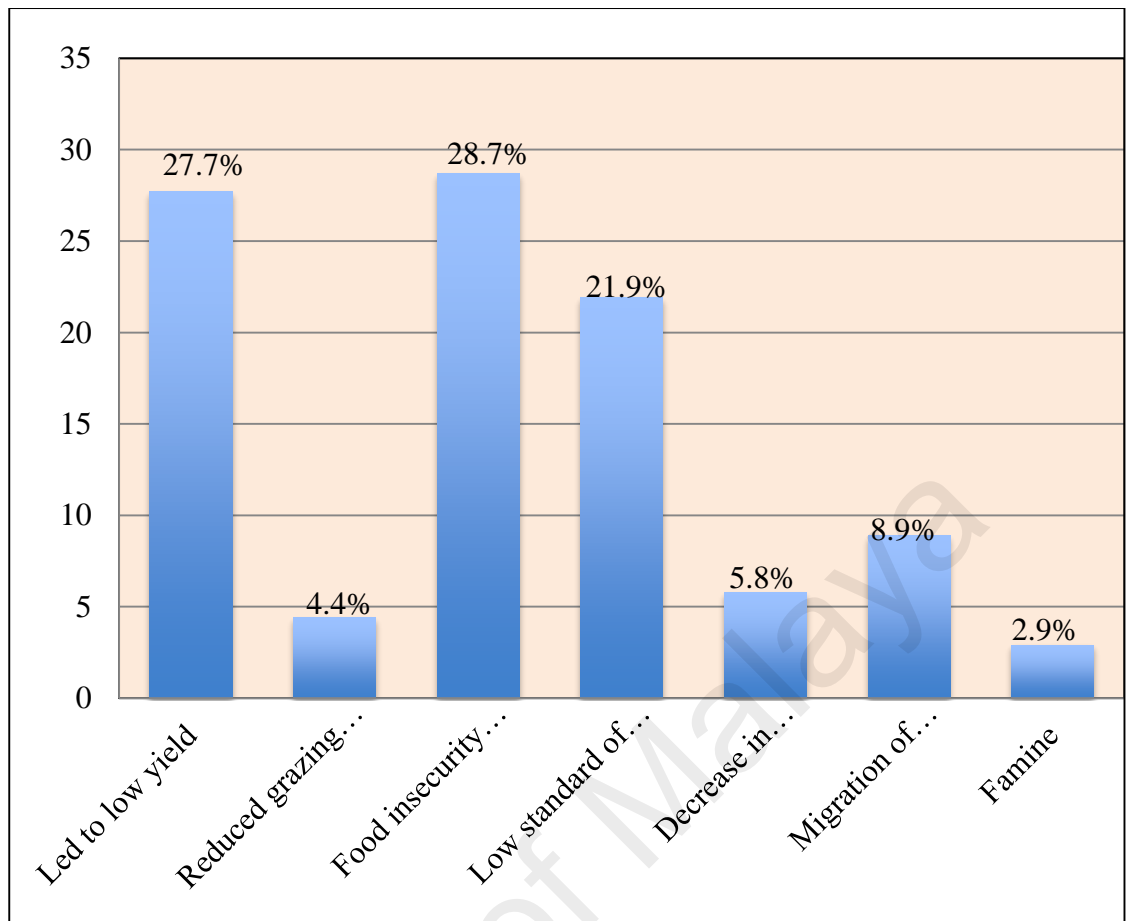


Figure 5.10: Farmers' perceived consequences of soil erosion

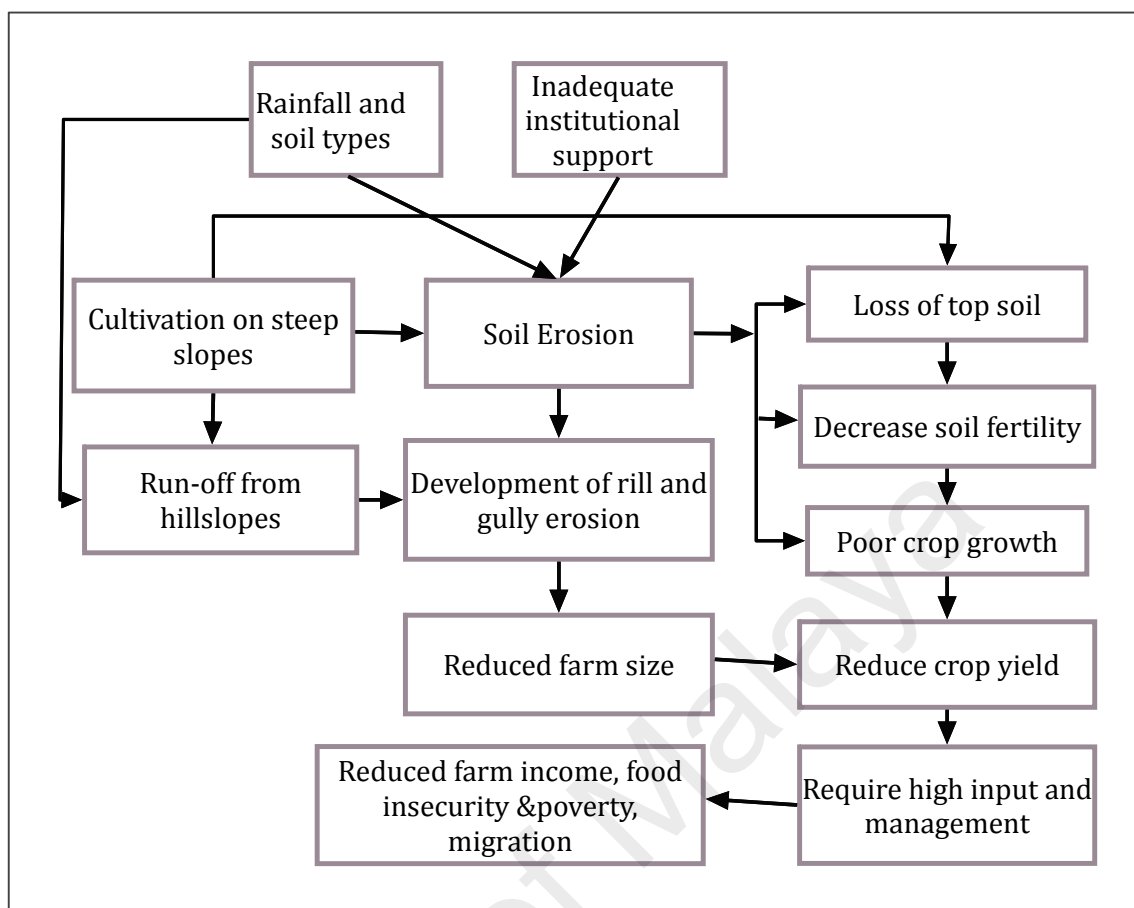


Figure 5.11: Farmers' perceived causes and consequences of soil erosion in the northern part of Taraba State, Nigeria

5.5.6 Perception of the trend of water erosion

This section covers farmers' perception of water erosion trends over the last ten years in the research region. Table 5.25 shows the farmers' perception with respect to the trend of water erosion over the last decade in the study region.

Table 5.25: Farmers' perception of water erosion trends over the last 10 years in the study region

Trend	Frequency of Responses	% Responses
Increasing	307	80.2
No change	48	12.5
Decreasing	28	7.3
Total	383	100

From table 5.25, the result indicates that the majority of the sampled farmers 80.2% perceived the trend of water erosion as increasing, while, 12.5% and 7.3% of the respondents perceived no change and a decrease in water erosion over the decade respectively (figure 5.12). This means that farmers in the research region have a high perception of the trend of water erosion increasing. This high percentage of farmers that perceived the trend of water erosion as increasing suggest that farmers in the research region are knowledgeable and have a high level of perception of water erosion on their individual farms. Thus, the farmers' are much more likely to effective adopt soil conservation measures on their farms.

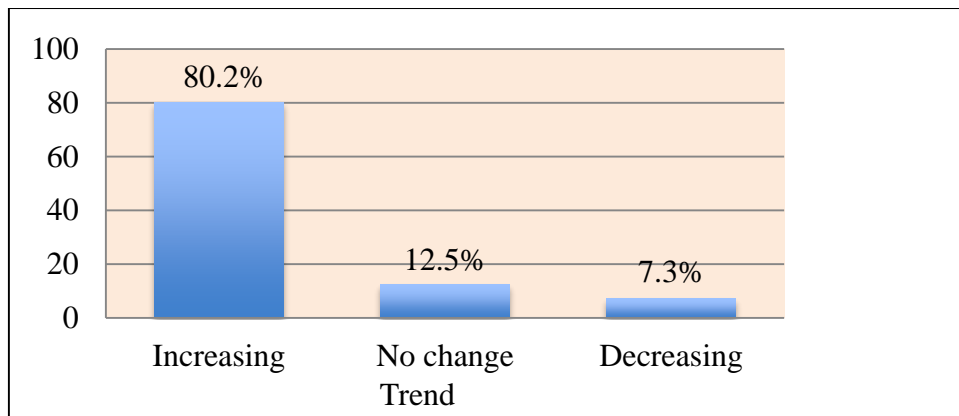


Figure 5.12: Farmers' perceived trends of water erosion over the last 10 years in the study region

5.6 Farmers' soil conservation measures for controlling soil erosion by water and fertility depletion

This section presents and interprete the results in three successive segments. The first segment appraises farmers' perception of soil erosion and their fertility depletion measures, agricultural systems, and the farmers' types of soil erosion and soil fertility control measures practiced in the study region. The second section explores farmers' perceptions about the effectiveness of the existing soil conservation methods practiced in the study region. Lastly, the third covers farmers' perception about the trend of soil fertility depletion over the last ten years in the study region.

5.7 Farmers' perceptions of soil erosion and Soil management measures

5.7.1 Farmers' perception of soil erosion control measures

This is about how farmers in the study region perceived soil erosion control measures on their individual farmlands. Table 5.26 shows the percentage of responses, which was calculated based on the frequency of occurrences of each response.

Table 5.26: Farmers' perception of soil erosion control

Do you think erosion can be controlled?	Frequency of Responses	% Responses
Yes	371	89.0
No	12	11.0
Total	383	100

From the table above, 89% of the farmers forming the majority believed that erosion could be controlled on their farms while the remaining 11% reasoned that erosion couldn't be controlled. This suggests the presence of a high-level perception among farmers that, soil erosion by water can be control on their individual farmlands. Hence, farmers' reasons for cultivating hill slope areas, while the flatlands provided by nature exist.

5.7.2 Farmers' adoption of soil erosion control measures

This is about whether the farmers in the study region adopt measures of water erosion control on their individual farmlands. Table 5.27 shows the percentage of responses, which were worked out, based on the frequency of occurrences of each response.

Table 5.27: Farmers’ adoption of soil erosion control on their individual farmlands

Do you adopt soil conservation measures for water erosion on your farm?	Frequency of Responses	% Responses
Yes	223	58.2
No	160	41.8
Total	383	100

The finding in table 5.27 revealed that the majority of farmers 58.2% practice soil conservation measures in their fields, while a relatively small proportion 41.8% didn't. This means that a greater proportion of the farmers in the study region practice some soil conservation measures for the control of water erosion. Suggesting, a large percentage of the entire agricultural field is conserved with water erosion measures.

5.7.3 Farmers’ level of adoption of soil erosion control measures

The level of adoption of soil erosion control measures is particularly fundamental where continuing soil erosion has remains the single most important soil degradation problem constraining farmers from achieving and acceptable level of food production. High level of adoption of soil erosion control measures halts erosion menaces. Table 5.28 shows the farmers’ perception with respect to their levels of adoption of water erosion control measures in the study region.

Table 5.28: Farmers’ level of adoption of soil erosion control measures on their individual farmlands

Level of adoption of soil erosion control measures	Frequency of Responses	% Responses
Low	189	49.3
Medium	67	17.5
High	127	33.2
Total	383	100

From table 5.28, the result reveals that the majority of the farmers 49.3% indicated that their level of adoption of soil erosion control measures was low. Only a small percentage of the respondents measuring 33.2% and 17.5% cited the high and medium level of adoptions respectively. This means that the farmers’ level of adoption of soil erosion control measures is low in research region. Suggesting water erosion may not be effectively halted.

5.7.4 Farmers’ perception of soil fertility

This is about how farmers in the study region perceived depletion of soil fertility on the individual farmlands. Such perceptions determine their degree of understanding about soil fertility depletion and its effects. However, farmers’ perceptions of soil fertility depletion do not only vary across culture through time, it also differs among various ethnic groups within villages, regions, and nations. The situation in the study region is as presented in table 5.29 below.

Table 5.29: Farmers' perception of soil fertility depletion in the study region

Do you see soil fertility depletion as a problem on your land?	Frequency of Responses	% Responses
Yes	321	83.8
No	62	16.2
Total	383	100

From the table above, the results indicate that the majority of farmers 83.8% perceived depletion of soil fertility, as a major problem on their farms, while a relatively small proportion 16.2% didn't. This means that the majority of the farmers in the research region perceived soil fertility depletion as a problem. Suggesting, therefore that, investment in solving the problem of fertility depletion through the adoption of different alternatives and conservation practices is expected.

5.7.5 Farmers' adoption of soil fertility control measures

This is about whether the farmers in the study region adopt soil fertility amendment measures on their individual farmlands. Table 5.30 shows the percentage of the farmers' responses with respect to their adoption of soil fertility measures on their individual farmlands.

Table 5.30: Farmers' adoption of soil fertility measures on their individual farmlands

Do you adopt soil conservation measures for soil fertility improvement on your farm?	Frequency of Responses	% Responses
Yes	196	51.2
No	187	48.8
Total	383	100

The finding with respects to the adoption of soil fertility measures in table 5.30, revealed that the majority of farmers 51.2% employed the practices of soil fertility measures in their fields, while 48.2% didn't. This means that a greater proportion of the farmers in the study region employed the practices of soil fertility measures on their individual farms. Suggesting, large percentage of the entire agricultural area in the research region are conserved with soil fertility control measures.

5.7.6 Farmers' level of adoption of soil fertility measures

One approach to offsetting soil degradation is to introduce optimum fertility control measures. Such measures involve soil conservation practices such as the application of organic amendments and inorganic fertilizers that replenish or improve the fertility of the soil. Both organic materials and mineral fertilizers protect the soil and increase crop yields. Thus, soil degradation can be reduced through the adoption of optimum level soil fertility control practices. Table 5.31 shows the percentage of farmers' responses with respect to their level of adoption of soil fertility measures on their individual farmlands in the study region.

Table 5.31: Farmers' level of adoption of soil fertility measures on their individual farmlands

Level of adoption of soil fertility measures	Frequency of Responses	% Responses
Low	114	29.8
Medium	219	57.2
High	50	13.1
Total	383	100

From table 5.31, the result reveals that the majority of the sampled farmers 57.2% indicated that their level of adoption of soil fertility measures was medium, while, 29.8% and 13.1% of the respondents cited the low and high level of adoptions respectively. This means that the level of adoption of soil fertility measures in research region is low. Suggesting there is a medium level of adoption of fertility measures in the study region and hence, soil fertility depletion problem may be improved.

5.7.7 Agricultural systems

Over 75% of the Nigeria population lives in rural areas and depends on soil resources for its means of livelihood. The farming systems and farming practices are characterized as subsistence agriculture. The examination of agricultural systems is essential to any study of the farmers and the understanding of soil erosion process as well as soil fertility relationship.

5.7.8 Types of implements as identified by farmers

The type of implements used in tilling the soil determined to a very great extent the emergences of soil erosion. Table 5.32 shows the percentage of farmers with respect to their use of different implements to till their farmlands in the study region.

Table 5.32: Type of tillage implements

Implement	Frequency of Responses	% Responses
Hoe	304	79.4
Animal traction	44	11.5
Tractor	35	9.1
Total	383	100

From table 5.32 it is evident that cultivation activity in the region is mainly done by hoe, which represents 79.4%, while, animal traction 11.5% and tractor 9.1%. This means that many farmers in the study region have actually embraced the use of the hoe. The reasons for higher usage of hoe in the study region could be due to small farm sizes, site and the ease with which they can use to cultivate their plots.

5.7.9 Type of crop (s) dominantly cultivated by farmers in the study region

This is about the different type of crops dominantly cultivated in the study region. Table 5.33 shows the percentage of farmers who dominantly cultivates different types of crops in the study region.

Table 5.33: Crop (s) dominantly cultivated by farmers in the study region

Crop	Frequency of Responses	% Responses
Yam	136	35.5
Groundnut	4	1.0
Guinea corn/maize	220	57.5
Cassava	17	4.5
Millet	4	1.0
Others	2	0.5
Total	383	100

From table 5.33, the finding indicates that the majority of the farmers 57.5% and 35.5% in the research region mentioned guinea corn/maize, and yam as the major food crop cultivated respectively. A significant proportion 4.5% cultivates cassava. Other crops least cultivated by farmers were millet 1.0%, and groundnut 1.0%. This means that farmers in the research region cultivate varieties of food crops on the farms.

5.7.10 Farmers' reason (s) for cultivating different types of crop (s) in the study region

This is about the farmers' reasons for cultivating different types of crop (s) in the study region. In the African traditional society, crops are cultivated for differences purposes depending on the farmers' socio-economic status. The prevailing situation in the study region is as presented in table 5.34.

Table 5.34: Farmers' reason for cultivating the different crop types

Reason for cultivating different crop types	Frequency of Responses	% Responses
Sources of food only	122	31.9
Sources of income only	48	12.5
Both food and income	213	55.6
Total	383	100

It is evident from table 5.34 that the farmers' reasons for cultivating the different type of crops were mostly for both sources of food and of income 55.6%. Other reasons mentioned by farmers in order of significance included as a sole source of food 31.9%, and of sole sources of income 12.5%. This means that the majority of the farmers in the research region cultivate their fields for a reason of a combination of a source of food and income.

5.7.11 Farmers' most common crop combination

The practice of cultivating different kinds of annual crops in farm provides better canopy cover and reduces soil erosion risk. Similarly, the sequential cropping practice, where the second crops mature under the soil residual moisture also helped in the soil fertility improvement. Table 5.35 shows the percentage of farmers' responses related to the most common crop combination practiced on their individual farmlands.

Table 5.35: Farmers' most common crop combination

Crop combination	Frequency of responses	% Responses
Yam with vegetable and groundnut	93	24.3
Yam with cassava and vegetables	69	18.0
Guinea corn with maize and beans	113	29.5
Guinea corn with beans	80	20.9
Maize with groundnut and millet	22	5.7
Others	6	1.6
Total	383	100

From table 5.35, the finding indicates that the majority of the farmers measuring, 29.5%, 24.3%, and 20.9 %, employed the practice of combining guinea corn with maize and beans, yam with vegetable and groundnut, and guinea corn with beans respectively. A relatively significant proportion practiced the combination of yam with cassava and vegetables on their individual farms (figure 5.13). This means that farmers in the research region practice the cultivation of different types of crops (intercropping) on their individual fields (figure 5.14). An indication, which suggests farmers' high level of awareness about erosion challenges, and the needs for soil fertility enhancements in the

research region. Therefore, this could be the farmer's reason for cultivating hill slopes, while there are flatland areas.

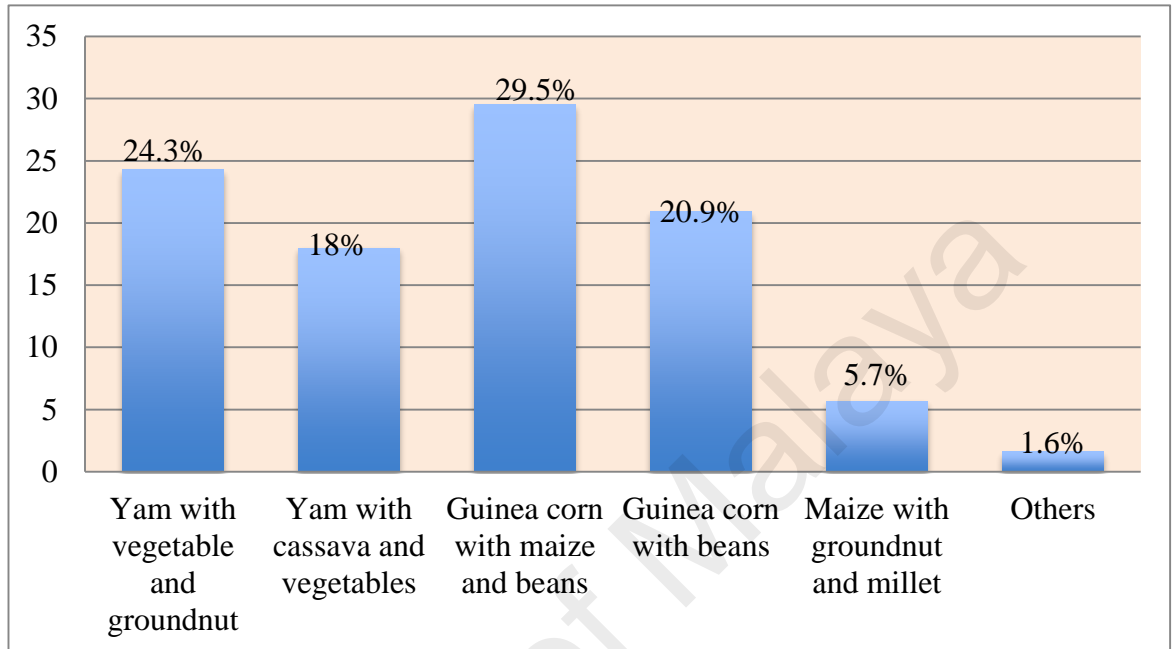


Figure 5.13: Farmers' most common crop combination



Figure 5.14: The most common crop combinations in the study region (A= Guinea corn with beans, B = Guinea corn with maize and beans)

5.7.12 Types of soil erosion control measures practiced in the study region

This is about the farmers' perceived water erosion control measures practiced in the study region. Table 5.36 shows the percentage of farmers who practiced different types of soil erosion control measures to mitigate on-farm water erosion in the study region.

Table 5.36: Farmers' types of soil erosion control measures being practiced to mitigate on-farm water erosion

Types of measures	Frequency of Responses	% Responses
Ploughing across the contour	96	25.1
Mulching	16	4.2
Ridges	63	16.5
Planting trees, use of grasses	29	7.6
Check dams	29	7.6
Waterways	44	11.5
Construction of bunds	91	23.8
Terracing	15	3.9
Total	383	100

From table 5.36, the results indicates that ploughing across the contour 25.1%, construction of bunds 23.8%, constructed of ridges 16.5%, and waterways 11.5%, were the most widely used traditional soil and water conservation measures by the farmer in the research region. A few percentage of farmers engaged in planting trees, and/or used for grasses 7.6%, and check dams 7.6%, to refill and/or prevent further development of rills and gullies near their farm boundaries (figure 5.15). Despite their wide fame, only a small percentage of the sampled farmers practice terracing and mulching. This means that farmers in the research region have good knowledge and practiced different forms of soil conservation measures to maintain infiltration and safe-disposal of run-off on their farms (figure 5.16). A condition, which suggests farmer's reason for cultivating, slopes while; there are flatland areas in the research region.

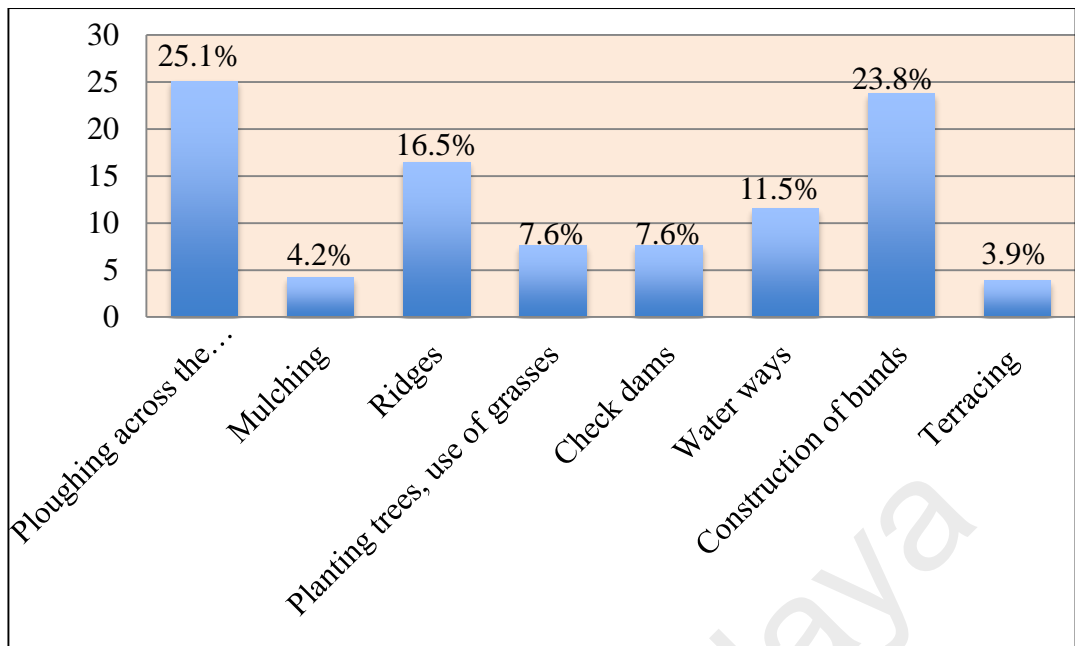


Figure 5.15: Farmers' types of soil erosion control measures being practiced to mitigate on-farm water erosion

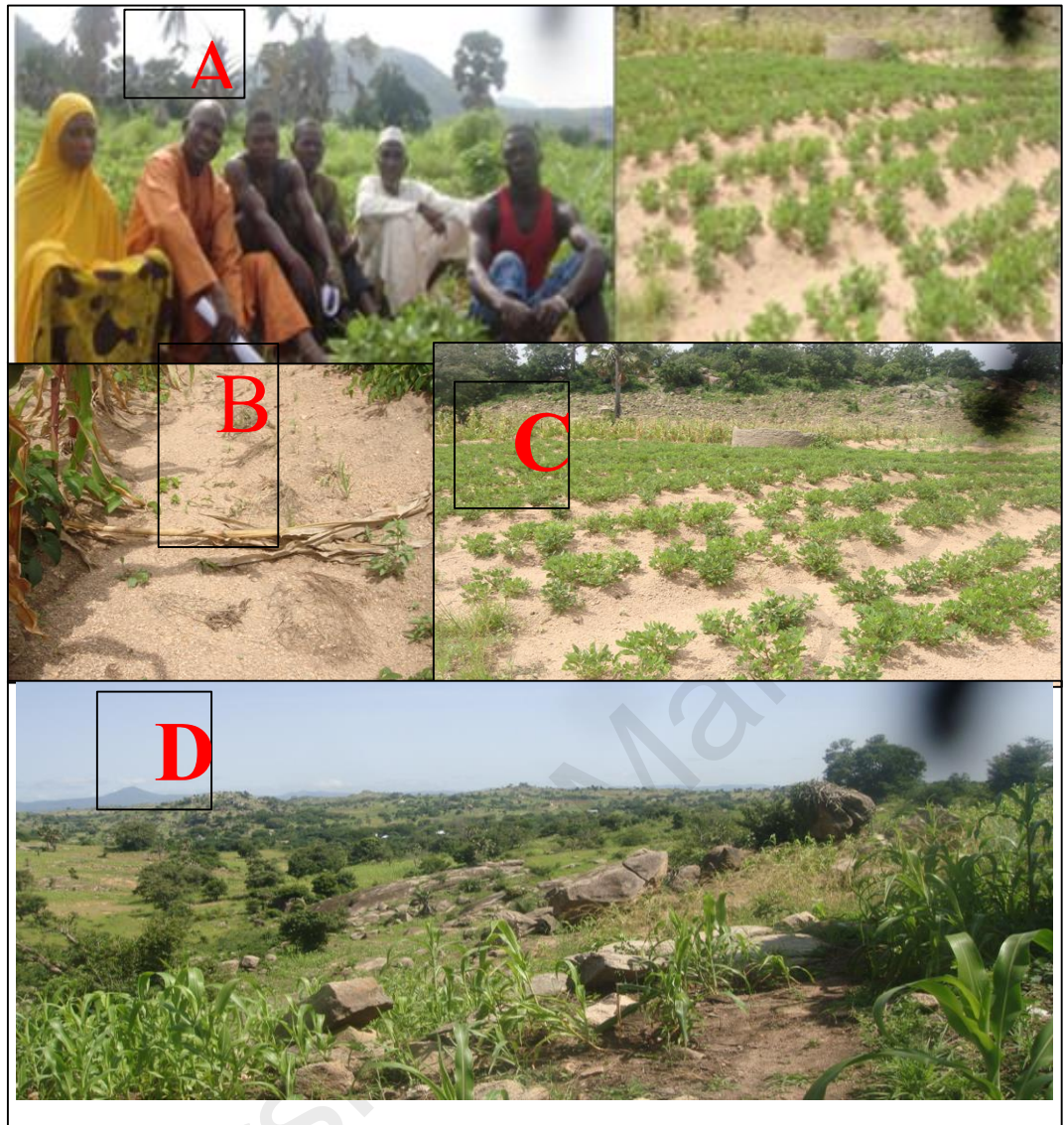


Figure 5.16: Sample of soil erosion control measures being practiced to mitigate on-farm water erosion (A= ridges, B= Water ways, C= planting trees, and/or used for grasses, D= Rock bunds)

5.7.13 Types of soil fertility amendments measure practiced in the study region

The types of soil fertility amendments measures practice determined the degree of soil fertility depletions. The application of inorganic fertilizers (NPK) and organic amendments (manure or compost) are the major soil fertility measures commonly practiced in the study region. Manure application is a traditional fertility management practice in the crop-livestock farming system common in the northern part of Taraba State. The livestock provides power for tillage, manure for organic matter and additional income for the purchase of mineral fertilizers. Manure is often obtained from mutually beneficial arrangements between farmers and herdsman, in which animals are corralled on farmers' fields in exchange for food or money. Hence, table 5.37 shows the percentage of farmers with respect to the different types of soil fertility measures practiced.

Table 5.37: Types of soil fertility measures practiced as identified by farmers in the study region

Types of soil fertility measures	Frequency of Responses	% Responses
Use of farmyard manure	67	17.5
Use of inorganic fertilizer	25	6.5
Use of compost and mulching	141	36.8
Crop rotation	32	8.4
Intercropping	116	30.3
Agroforestry	2	0.5
Total	263	100

From table 5.37, the results indicated that use of compost and mulching by 36.8%, intercropping 30.3%, and use of farmyard manure 17.5%, was the most widely used

traditional soil fertility enhancement practices in the research region. Significant proportions of the farmers practiced crop rotation 8.4% and used of inorganic fertilizer (chemical fertilizer) 6.5%. A relatively very few farmer used Agroforestry to enhance the soil fertility status of their farms (figure 5.17). This means that farmers in the research region have, and are using different conservation measures to enhance the fertility status of their agricultural lands. A condition that suggests, farmer's high level of awareness of soil fertility depletion impact, and thus, the reason for cultivating hill slope areas, while the flatlands exist.

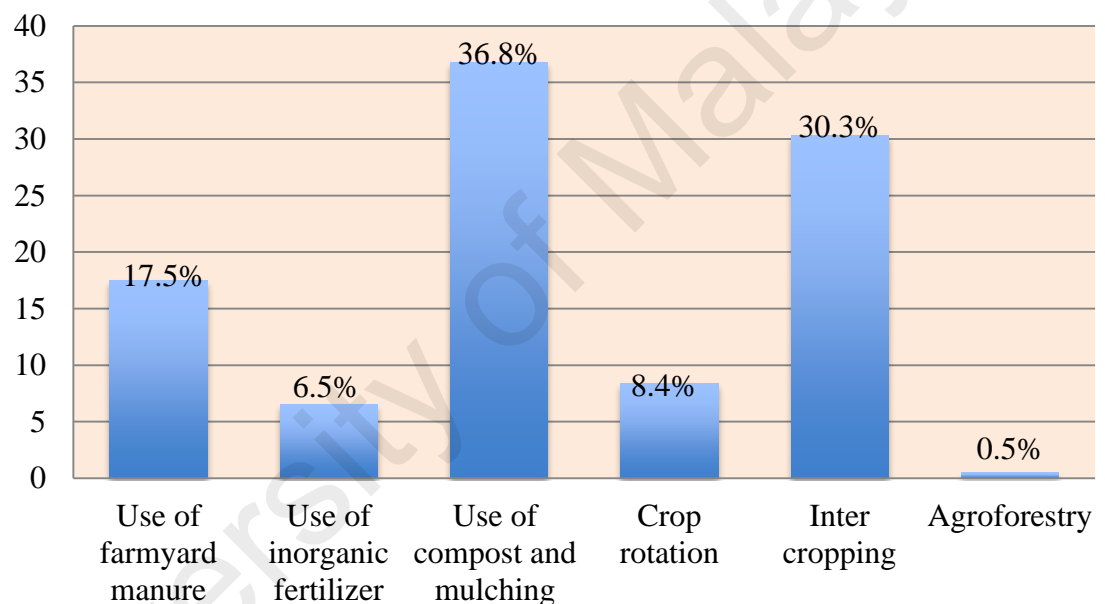


Figure 5.17: Types of soil fertility measures practiced as identified by farmers in the study region

5.7.14 Farmers' soil fertility depletion indicators

This is about how farmers in the study region recognize soil fertility depletion indicators on their individual farms. Table 5.38 shows the percentage of responses, which was calculated based on the frequency of responses.

Table 5.38: Soil fertility depletion as identified by farmers in the study region

Soil fertility depletion indicators	Frequency of Responses	% Responses
Reduce crop yield	112	29.2
Poor crop performance	61	15.9
Yellowing of the crop	197	51.4
Others	13	3.4
Total	383	100

From table 5.38, the result shows that the major indicators farmers mentioned are; yellowing of the crops 51.4%, and a reduction in crop yields 29.2%. A significant proportion of the farmers constituting 19.5% mentioned poor crop performance, and others 3.4% (figure 5.18). This means that farmers in the research region are aware that soil fertility depletion in various forms is taking place on their farmlands. This is based on their perception and interpretation of all indicators that reveal certain conditions regarding soil fertility depletion. Hence, this could be the farmer's reason for cultivating hill slopes while flatland exists.

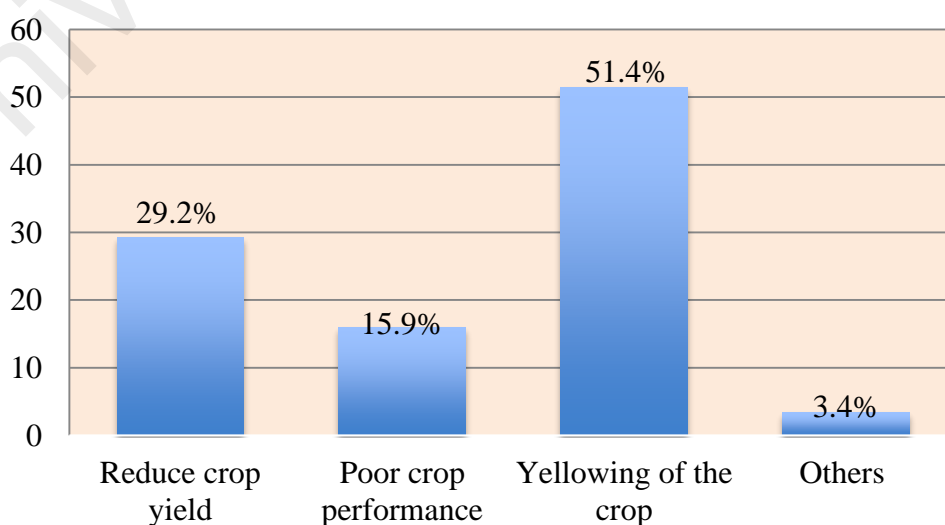


Figure 5.18: Farmers' soil fertility depletion indicators

5.8 The effectiveness of the different types of soil erosion and soil fertility control measures practiced in the study region

The second section explores farmers' perceptions about the effectiveness of the existing traditional soil conservation methods practiced in the study region.

5.8.1 The effectiveness of the different types of soil erosion control measures practiced in the study region

This is about the farmers' perceived effectiveness of the different types of soil erosion control measures practiced in the study region. Table 5.39 shows the percentage of responses, which was calculated based on the frequency of responses.

Table 5.39: Farmers' perceived effectiveness of the different types of soil erosion control measures practiced on their individual farms

Farmers' perceived effectiveness	Frequency of Responses	% Responses
Ploughing across the contour	86	22.4
Mulching	35	9.1
Ridges	47	12.2
Planting trees, use of grasses	24	6.3
Check dams	29	7.5
Water ways	45	11.7
Construction of bunds	84	21.8
Terracing	35	9.1
Total	383	100

From table 5.39, the results indicates that ploughing across the contour 22.4%, construction of bunds 21.8%, construction of ridges 12.2% and waterways 11.7%, were the most widely perceived as effective of the existing traditional soil conservation

methods practiced in the study region. Surprisingly, a relatively significant proportion of farmers 9.1% and 9.1%, as effective perceived mulching and terracing. This is followed by check dams 7.5%, and planting trees, and/or used of grasses 6.3% as least perceived (figure 5.19). This implies that farmers in study region have recognized the efficiencies all the soil erosion control measures, but perceived ploughing across the contour, construction of bunds, construction of ridges and waterways as the most effective measures capable of preventing soil erosion phenomenon on their crop fields. An indication, that also suggests farmer's high level of awareness of erosion control alternatives and the reason for cultivating hill slopes while flatlands exist.

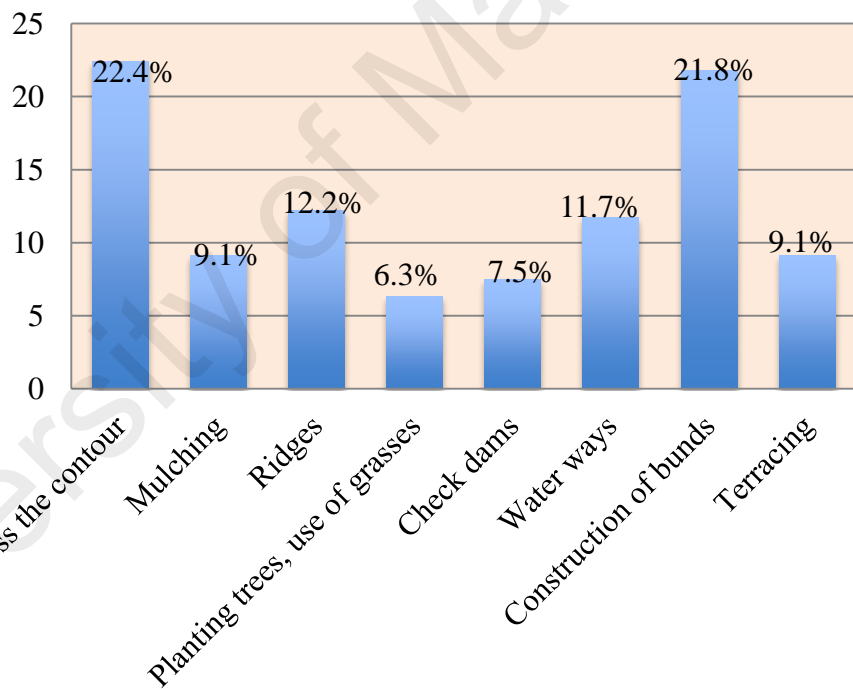


Figure 5.19: Farmers' perceived effectiveness of the different types of soil erosion control measures practiced on their individual farms

5.8.2 The effectiveness of the different forms of fertility amendments measures practiced in the research region

This is about the farmers' perceived effectiveness of the different types of soil fertility enhancement measures practiced in the study region. Table 5.40 shows the percentage of responses, which was calculated based on the frequency of responses.

Table 5.40: Farmers' perceived effectiveness of the different types of soil fertility measures practiced on their individual farms

Farmers' perceived effectiveness	Frequency of Responses	% Responses
Use of farmyard manure	86	22.5
Use of inorganic fertilizer	101	26.4
Use of compost and mulching	59	15.4
Crop rotation	45	11.8
Intercropping	61	15.9
Agroforestry	31	8.1
Total	383	100

From table 5.40, the results indicated that the majority of the farmers, 26.4%, and 22.5%, perceived use of inorganic fertilizer, and farmyard manure, as the most effective forms of the existing traditional soil fertility enhancement measures practiced in the study region. A significant percentage of the farmers as effective, perceived the use of compost and mulching 15.4% and intercropping 15.9%. Crop rotation 11.8, and Agroforestry 8.1% follow these uses, as least perceived (figure 5.20).

This means that farmers in the research region have a wealth of knowledge and experiences about the practicality and efficiency of all the soil fertility alternatives practiced. This is based on the ability to perceive all the forms of soil conservation

alternatives for soil fertility enrichments. A condition that also suggests, farmer's high level of awareness of soil erosion problems, in the form of soil fertility depletion, and hence, reasons for cultivating hill slope while, flatlands provided by nature exist.

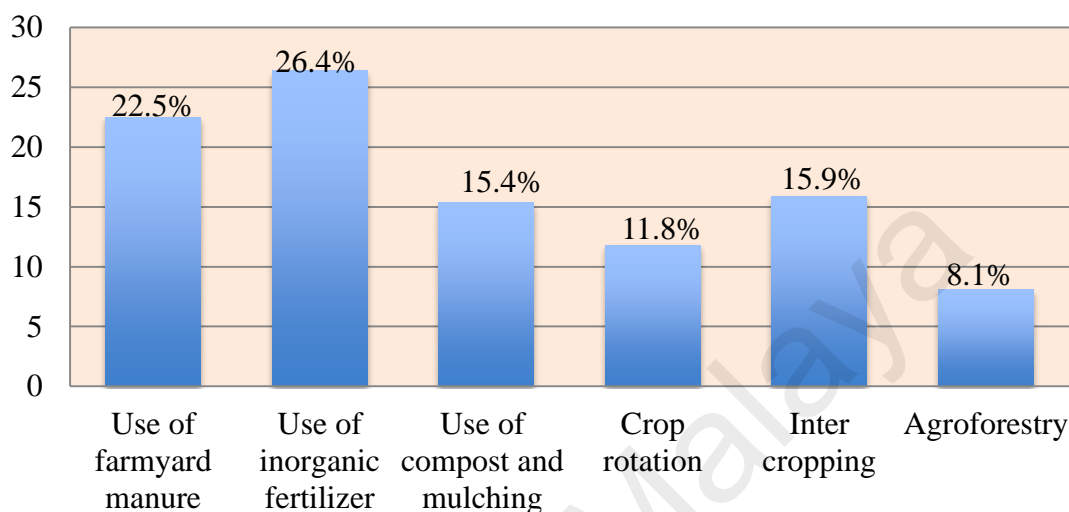


Figure 5.20: Farmers' perceived effectiveness of the different types of soil fertility measures practiced on their individual farms

5.9 The trend of soil fertility status in the study region

This section covers the farmers' perception about the trend of soil fertility depletion over the last ten years in the study region. Table 5.41 shows the farmers' perception with respect to the trend of soil fertility over the last decade in the study region.

Table 5.41: Farmers' perception of the trend of soil fertility on their individual farm plots

Years	Frequency of Responses	% Responses
Decreasing	279	72.8
No change	64	16.8
Increasing	40	10.4
Total	383	100

From table 5.41, the results indicates that the majority of the respondents 72.8% reported decreasing as the current trend of soil fertility status on their farm. A relatively significant proportion of the farmers 16.8% mentioned no change, followed by increasing 10.4% (figure 5.21). This means that the majority of farmers in the research region have a high perception of soil fertility status of their individual farms decreasing. This, therefore, suggests that farmers in the research region have a high level of awareness and might employ different forms of soil conservation alternatives for soil fertility enrichments.

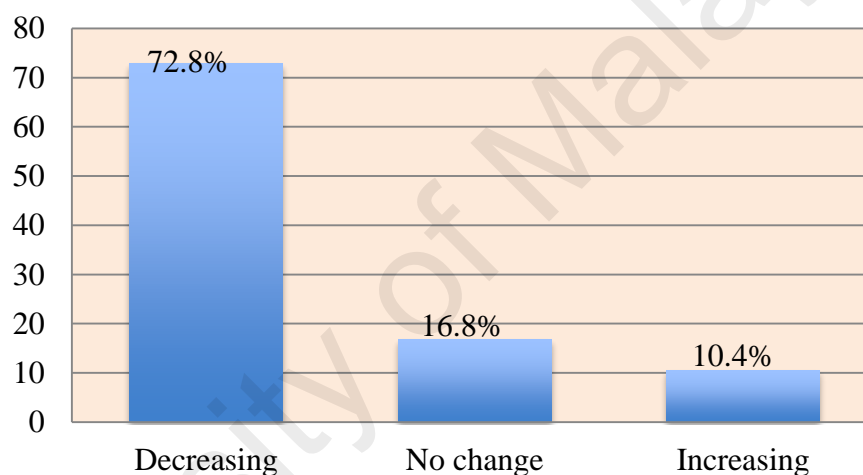


Figure 5.21: Farmers' perceived trend of soil fertility in the study region

5.10 Farmers adoption of soil conservation measures in the study region

This section evaluates farmer perception regarding their practice of soil erosion and fertility depletion measures. The first segment covers the farmer's participation in local organizations and the types of services needed to control soil erosion and fertility depletion in their farm. The second covers the farmers' perception about the sufficiency, timely, and frequency of services provided by extension agents for soil erosion and fertility depletion control in the study region. The third segment evaluates the relationship between farmers' adoption of soil conservation measures and their perception of water erosion and fertility depletion as a problem. Lastly, the fourth phase

covers the evaluation of farmers' perceived trend of water erosion and soil fertility depletion and their level of adoption of soil conservation measures.

5.11 Farmers' participation in local organizations and types of services needed to control soil erosion and fertility depletion on their farm

This section explored the farmers' perception about their participation in local farmer's organizations and types of services needed to control soil erosion and fertility depletion on their farm

5.11.1 Farmers' participation in local organizations

Land users association at the grassroots level plays a major role in dealing with soil erosion and fertility depletion problems. Local organizations with appropriate support and encouragement could facilitate participatory development and help to address soil erosion and fertility depletion problems. Table 5.42 shows farmers' responses with respect to their participation in local farmers association in the study region.

Table 5.42: Farmers' participation in local farmers association to control soil erosion and fertility depletion on their farms

Do you belong to a farmers' association or some local association?	Frequency of Responses	% Responses
Yes	314	82.0
No	69	18.0
Total	383	100

From table 5.42, the results indicated that the majority of the farmers 82% belong to some types of farmers association or some local association, but 18% are not organized

in local organizations. This means that the majority of farmers in the research region are actually organized in local associations. A condition that suggests, soil erosion and fertility depletion problems might be addressed effectively.

5.11.2 The needs for assistances to control soil erosion and fertility depletion

This is about whether the farmers in the study region needed some assistance to control soil erosion and fertility depletion on their farms. Table 5.40 shows the percentage of responses, which was calculated based on the frequency of responses.

Table 5.43: Farmers' needs for assistance to control soil erosion on their farms

Do you need some assistance to control soil erosion and fertility depletion on your land?	Frequency of Responses	% Responses
Yes	377	98.9
No	6	1.6
Total	383	100

From table 5.43, the results showed that the majority of farmers 98.9% reported that they needed assistances to control soil erosion and fertility depletion on their individual farms. While, the remaining 1.6% opted for no need. This means that most farmers of the research region needed assistances to control soil erosion and fertility depletion on their farms. This high percentage of farmers needing assistances implies that most of the resource farmers are poor who could not afford optimum replacement of lost soil quality on their individual farms.

5.11.3 Types of assistance needed by farmers to control soil erosion and fertility depletion on their farms

This is about the different types of assistance needed by the farmers to control soil erosion and fertility depletion on their farms in the research region. Table 5.44 shows the percentage of responses, which was calculated based on the frequency of responses.

Table 5.44: Farmers' types of assistance needed to control soil erosion and fertility depletion on their farms

Types of assistance needed	Frequency of Responses	% Responses
Agricultural loan	222	58.0
Modern soil conservation techniques	15	3.9
Timely distribution of farm inputs	85	22.2
Control price of farm produce	47	12.3
Demonstration plots	12	3.1
Farmers education	2	0.5
Total	383	100

From table 5.44, the finding showed that the majority of the farmers, respectively, 58.0%, 22.2%, and 12.3% mentioned agricultural loan, timely distribution of farm inputs, and control price of farm produce as the types of assistance much needed to control soil erosion and fertility depletion in the study area. A relatively small percentage of farmers 3.9% and 3.1%, mentioned modern soil conservation techniques and establishment of demonstration plots. While, farmers education 0.5%, was the least mentioned form of assistance needed. This means that farmers recognize the importance of all types of assistances in agricultural practices. But perceived as a most effective agricultural loan, timely distribution of farm inputs, and control price of farm produce. This perceived importance of all types of assistances in agricultural practices suggests

that the farmers have a high level of awareness and experiences. Thus, could be the reason for cultivating hill slopes while flatland exists.

5.12 Extension agents

In most developing countries of the world, extension agents play a significant role in providing information and appropriate services, as well as in facilitating and encouraging local farmers' organizations. Such, information and services, are necessary requirements for educating and inspiring farmers to practice effective soil conservation measures to combat soil erosion and fertility depletion. Thus, this section covers the farmers' perception about their access and the sufficiency, timely, and frequency of services provided by extension agents to control soil erosion and fertility depletion in the study region.

5.12.1 Farmers' access to extension agents in the study area

Having access and good relation with extension agents creates mechanisms for providing information and appropriate technologies. Thus, extension agents help farmers reduce hazard associated with soil erosion and conservation, by providing information and appropriate technologies to combat soil erosion and fertility depletion. Table 5.45 shows the percentage of farmers with respect to their access to extension agents in the study area.

Table 5.45: Farmers' access to extension agents in the last 5 years

Do you have access to extension agents	Frequency of Responses	% Responses
Yes	72	18.8
No	311	81.2
Total	383	100

From table 5.45, the results showed that the majority of the farmers 81.2% have no access to extension agents in the last five years, only 18.8% do. This means that majority of the farmers in the research region do not have access to extension agents. This lack of access to extension agents, while crop productivity, relatively sustained in the research region suggests, the farmers' used off and the effectiveness of the traditional soil conservation measures of controlling soil erosion by water and soil fertility depletion. Hence, farmer's reason for cultivating slopes while flatlands exist.

5.12.2 Types of extension services benefited by farmers in the last five years

Though, farmers might have good knowledge of the existence and level of soil erosion and fertility depletion, in terms of its causes, extents and consequences on their farmlands. Yet, extension services are required to stimulate or enhance farmers' willingness to accept and adopt effective soil conservation measures. Table 5.46 shows the percentage of farmers who had access to extension agents with respect to the different types of extension services benefited in the study region.

Table 5.46: Types of extension services benefited by farmers in the last five years

Types	Frequency of Responses	% Responses
Use of improved varieties of crops	43	59.7
Soil conservation techniques	7	9.7
Enhancing soil fertility	22	30.6
Yield maximization	0	0
Yield storage system	0	0
Demonstration plots	0	0
Total	72	100

From table 5.46, the finding revealed that the majority of the farmers, respectively, 59.7%, and 30.6%, cited the use of improved varieties of crops, and soil fertility enhancement as the major types of extension services benefited in the study region. While, 9.7% mentioned the practice of soil conservation techniques and none mentioned any other forms of service benefited. This means that the majority of the farmers in the research region have not benefited much from the different types of extension services. Hence, extension services are insufficient.

5.12.3 How often does extension agents visit you in a year

This is about the frequency of extension agents visit to farmers on their farms/ village in the study region. Table 5.47 shows the percentage of responses, which was calculated based on the frequency of responses

Table 5.47: Number of time extension agents visits farmers in a year

Number of time	Frequency of Responses	% Responses
1 -2	69	95.8
3-4	3	4.2
5-6	0	0
7 and above	0	0
Total	72	100

From table 5.47, the majority of the farmers 95.8% indicated that extension agents visit them one to two times, while, the remaining 4.2% were visited between 3-4 times, none of the farmers were visited more than 4 times. This means that the number of times extension agent's pay visits to farmers in the research region is very low. Suggesting, vital information and technologies or services that are necessary

requirements for educating and inspiring farmers to practice effective soil conservation measures to combat soil erosion and fertility depletion is lacking in the study region.

5.12.4 Farmers' level of satisfaction with the services rendered

This is about whether the farmers who had access to extension agents, satisfied with the level services rendered to them by the extension agents in the study region. Table 5.48 shows the percentage of responses, which was calculated based on the frequency of responses.

Table 5.48: Farmers' level of satisfaction with the services rendered by extension agents in the study area

Are you satisfied with the services rendered by extension agents?	Frequency of Responses	% Responses
Yes	0	0
No	72	100
Total	72	100

From table 5.48, the finding showed that all the farmers indicated that they were not satisfied with the level of extension services provided them to practice soil conservation measures. This means that there was no effective extension services provided to farmers in the research region during the years under review. Suggesting extension services, which facilitate and encourage the farmers to practice soil conservation measures were lacking in the study region.

5.13 The relationships between farmers' adoption of soil conservation measures versus their perceptions of water erosion and fertility depletion as a problem

In assessing how farmers perceived water erosion and fertility depletion in each of their plots during normal cropping years, farmers were asked two major questions: 1. Was water erosion perceived as a problem on their land (1= yes, 2= no)? 2. Farmers were asked whether they perceived soil fertility depletion as a problem (1= yes, 2= no)? The results showed that a greater proportion of the farmers (91.9%) indicated a generally high level of awareness and perception of water erosion as a problem on their farms (Table 5.15). Similarly, the majority (83.8%) of farmers reported that soil fertility depletion was a problem on their farms (Table 5.29).

Given the above results, there is an apparent contradiction. Farmers perceived water erosion and soil fertility as a problem on their farms, but their adoption of soil conservation measures for water erosion (Table 5.27) and soil fertility (Table 5.30) was small and moderate respectively. To confirm this contradiction, a chi-square X^2 analysis was used to test the association between farmer adoption of soil conservation (1= yes, 2= no) and their perception of soil erosion as a binary choice (1= yes, 2= no) on one hand, and the farmer adoption of soil conservation (1=yes, 2=no) and their perception of soil fertility as a binary choice (1=yes, 2=no) on the other.

Two hypotheses for farmers' perceptions of water erosion and fertility depletion versus of adoption of soil conservation were proposed

1. If farmers are aware of water erosion as a problem, they are more likely to adopt the practices for water erosion control measures.
2. If farmers perceive soil fertility as a problem, they are more likely to adopt soil fertility control measures.

5.13.1 The relationship between farmers' adoption of soil conservation measures and their perception of water erosion and fertility depletion as a problem

Table 5.49, presents relationships between farmers' adoption of soil conservation measures and their perceptions' regarding both water erosion and fertility depletion.

Table 5.49: The associations between farmers' adoption of soil conservation and their perceptions regarding both water erosion and fertility depletion (using X^2 test) in the study region

Perception	Adoption in water erosion control	Adoption in soil fertility control
	X^2 (p value)	X^2 (p value)
Water erosion is a problem	2.252 (0.183)	4.177 (0.041)
Soil fertility decline is a problem	0.666(0.482)	383.00(0.000)

The X^2 test results in table 5.49, shows that respondent perceptions of water erosion as a problem are not significantly associated with their adoption of water erosion and soil fertility control measures ($X^2= 2.252$, $p=0.18$) and ($X^2= 4.177$, $p=0.041$), respectively (Appendix F). This means that the null hypothesis was not rejected. Implying farmers who perceive water erosion as a problem on their land do not adopt significantly ($p<0.05$) more than do farmers who do not perceive water erosion as a problem.

However, the X^2 test with respect to the respondent perceptions of soil fertility decline as a problem is significant in the level of significance of the correlation with the adoption of soil fertility control measures ($X^2= 383.000$, $p=0.000$). This means that the null hypothesis was rejected. Implying, farmers who perceive soil fertility depletion as a problem on their land do adopt significantly ($p<0.05$) more than do farmers who do not

perceive fertility depletion as a problem. Though, it is not significantly associated with the adoption of water erosion measures ($X^2 = 0.666$, $p = 0.482$).

5.14 The relationship between the farmers' perceived trend of water erosion and soil fertility depletion and their level of adoption of soil conservation measures in the study region

In assessing how farmers perceived the trend of water erosion and soil fertility depletion over the last decade, farmers were asked two major questions: 1. How did they perceive the trend of water erosion over the past 10 years (1=increasing, 2=no change, 3=decreasing), and the current trend in the depletion of soil fertility (1=increasing, 2=no-change, 3=decreasing)?

The results indicate that 80% of the sampled respondents strongly perceived an increasing trend in water erosion (Table 5.25), and a significant proportion (60.3%) affirmed the view that soil fertility had been declining over the past decade (Table 5.41). Given the above results, there is an apparent contradiction. Farmers perceived an increasing trend in water erosion and declining soil fertility on their farms, but their levels of adoption in water erosion and soil fertility measures were comparatively low and medium (Table 5.28) and (Table 5.31) respectively.

To confirm this contradiction, the relationship between the perceived trend of soil erosion and the level of adoption in water erosion control measures by farmers was tested using a Spearman correlation analysis. Ordinal variables (1=increasing, 2=no-change, 3=decreasing and 1=no/low, 2= medium, 3= high) were used to evaluate farmer perceptions of the trend of erosion and their levels of adoption. Similarly, the relationship between the perceived trend of soil fertility depletion and the level of adoption in soil conservation by farmers was tested using a Spearman correlation analysis. Ordinal variables (1=increasing, 2=no-change, 3=decreasing and 1=no/low,

2=medium, 3=high) were used to evaluate farmer perceptions of the trend of soil fertility and their levels of adoption.

Two hypotheses for farmer perceptions of the trend of soil erosion and soil fertility decline versus the level of adoption of soil conservation measures were proposed

1. If farmers perceive that water erosion is increasing over time, they increased the level of adoption of practices for water erosion control measures.
2. If farmers perceive soil fertility degradation over time, they will increase the level of adoption of soil fertility control measures.

Table 5.50, presents relationships between the farmers' levels of adoption in soil conservation and their perceptions regarding both the trend of water erosion and fertility depletion.

Table 5.50: The associations between farmers' level of adoption of soil conservation and their perceptions regarding both the trend of water erosion and fertility depletion (using Spearman correlation) in the study region

Perception	Level of adoption in water erosion control	Level of adoption in soil fertility control
	Spearman (p value)	Spearman (p value)
Water erosion increase over the years	-0.027(0.602)	-0.061(0.232)
Soil fertility depletes over the years	0.155 (0.002)	0.036(0.482)

The results in table 5.50, revealed an insignificant Spearman correlation between the farmer levels of adoption in water erosion and fertility control with their perceptions of the trend of water erosion ($r = -0.027$, $p=0.60$) and ($r = -0.061$, $p=0.23$) respectively. Similarly, an insignificant correlation between the farmer levels of adoption in soil fertility control and their perceptions of the trend of soil fertility ($r=0.036$, $p=0.482$) was recorded. This means that the entire null hypothesis was not rejected. Suggesting,

farmer perceptions of soil erosion and fertility depletion do not influence their level of adoption in soil conservation measures. In another word, this implies that most farmers in the study area perceive increasing water erosion and declining soil fertility as an increasing problem, this perception does not significantly influence their decisions to increase the level of adoption in soil conservation or water erosion and soil fertility control measures.

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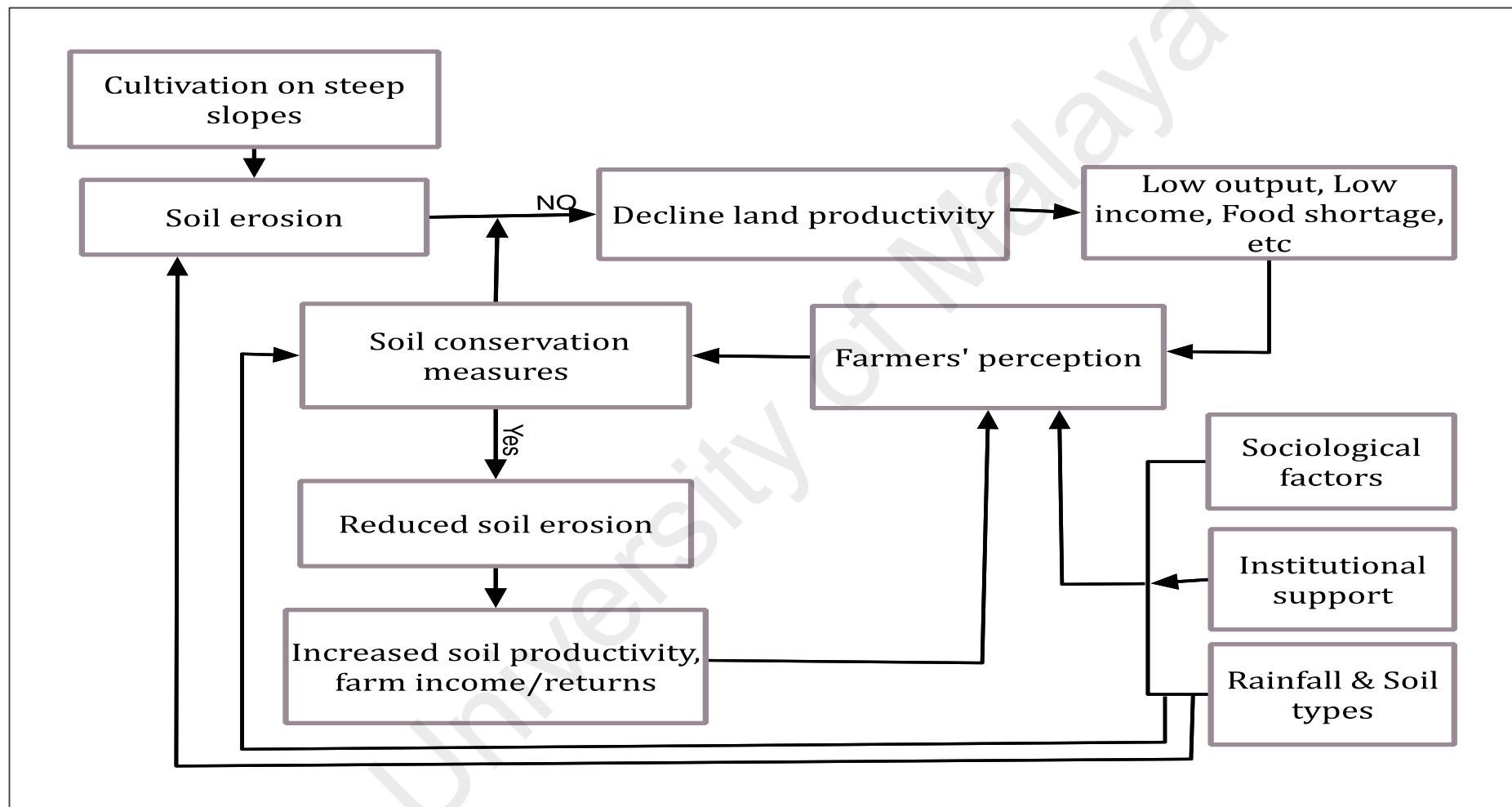


Figure 5.22: Final model: Soil erosion: Farmers' perception and conservation measures in the northern part of Taraba State, Nigeria

CHAPTER 6: DISCUSSION

The preceding chapter has been able to present the empirical data of the study. This chapter discusses some of the major issues that were salient in the preceding chapter, but which form the major findings of this research.

6.1 Farmers' perception of soil erosion

This section discusses the results in four successive sections. The first segment discusses some personal and demographic characteristics of farmers and their land ownership. The second section covers farmers' perceptions of soil erosion and preferences for cultivating hill slopes in the study region. The third section discusses farmers' perceptions of the factors associated with soil erosion problem and its indicators, effects and consequences. Lastly, the fourth section covers farmers' perception of the trend of water erosion over the last ten years in the research region.

6.2 The socio-economic characteristics of farmers in the study region

Farmers who are of independent age group undertake the practice of different soil conservation measures better (Omeregbee *et al.*, 2013). The study revealed that the majority of the sampled farmers (57.4%) were middle age (Table 5.1). This finding is conformity with the idea that most farmers in the African traditional society are of middle age (Udayakumara *et al.*, 2010). Farmers of middle-aged were more enthusiastic and have more work efficiency (Okoye *et al.*, 2008). In addition peasant, farmers of middle-aged have more physical vigor and have more family responsibilities than the young and old farmers (Matata *et al.*, 2010). This implies an economically strong and active farming population, and thus, the farming population in study region is quite active and has the potentials for increasing productivity and earnings through the

adoption of soil conservation measures. Hence, farmers' reason for cultivating hill slope while flatland exists.

The results with respect to sex showed that a greater percentage of the sampled farmers (88.3%) were male. Implying, the tedious traditional practices of different conservation measures that require more physical vigor to control water erosion and enhance the fertility status agricultural lands can be undertaken. The greater percentages of male sampled could be related to the fact that women in the study region depend on their husbands for a livelihood. This result is conformity with the idea that in the African traditional societies the women rarely claim ownership of farms and usually regards their husbands as the owners of the family farms (Basu *et al.*, 1986; Ogunlela & Mukhtar, 2009).

The educational status of a farmer particularly literacy level is among the main factors that determined the development and growth of a society (Sattler & Nagel, 2010). It creates awareness among farmers and influences their perception about the adoption of strategies and techniques that can prevent or curb erosion and fertility depletion (Tenge *et al.*, 2004; Udayakumara *et al.*, 2010). Survey results indicate that the majority of farmers sampled were literates (Table 5.4). This implies that the farmers are in a better position to be aware or understand soil erosion and adopt conservation measures. This result with regard to the formal education of farmers followed up similar results obtained by (Akinagbe & Umukoro, 2011; Ozor *et al.*, 2013) in Nigeria and consistent with other results reported across African countries by Bewket (2011); Tenge *et al.*, (2004), where farmers who were identified as having a good educational status, were found to participate more in soil conservation measures with reference to illiterate farmers.

According to Wauters *et al.*, (2010); Wolka *et al.*, (2013), formal education is a critical factor in the acquisitions and a better understanding of the concepts of soil erosion and conservation measures. It widens the horizons of an individual farmer by gaining knowledge, which might result in better soil conservation measures. Hammad & Borresen (2006), discussed that formal education increased the farmers' ability to receive, decode and understand information relevant to soil erosion processes and conservation measures on their fields, and thus, makes innovative decisions. In addition Huffman (2001), had earlier noted that, both theoretically and empirically, farmers, with formal education possess high-allocated ability and adjust faster to the understanding of soil erosion and fertility depletion on their farms. Hence, by implication, the farmers in the study region possess high-allocated ability and can adjust faster to the understanding of soil erosion and fertility depletion on their farms. Therefore, this could be the farmers' reason for cultivating hillslopes while flatland exists.

The results with regards to household size showed that the majority of the farmers have a large family size of 5-8 members (Table 5.5). This corroborated some findings that rural dwellers tend to have large families in most African societies (Jayne *et al.*, 2003; Kabubo-Mariara *et al.*, 2009). However, it is pertinent to note that, the influence of household size is dependent on the composition of the households. Generally, large household's sizes, particularly, with the majority capable of working are a proxy for labour availability. It influenced the adoption of soil conservation positively as its availability reduces the labour constraints. On the other hand, it will have negative effects where household's size is larger with many mouths to eat rather than to work.

The result with regard to farm income shows that the majority of the farmers in the research region earned low income from their farm proceedings annually (Table 5.6). This was confirmed through in-depth interviewed with the farmers and the traditional

community agricultural chiefs (locally titled *Sarkin Noma*). Inadequate, irregular and ineffective extension services were the farmers' reasons. This is consistent with the finding of the previous study, which revealed that farmers in northern Nigeria earned less income annually from their farm precedence compared to their counterparts in the southern regions (Babatunde, 2008; Babatunde & Qaim, 2010). Income is a key variable, which impacts on farmers' farming decision. Thus, low income may have a negative impact on farmers farming decision and hence, result in increased soil erosion and fertility depletion.

High agricultural economic efficiencies increased farmers' enthusiasm for agricultural investments (Ali *et al.*, 2007; Kristensen *et al.*, 2001). Under relatively high-income level, high demand for outputs, besides the personal perception of the individual farmers, farmers tend to increase their efforts in soil erosion control and soil fertility improvement. For instance, having off-farm income was found to influence the farmers' willingness and ability to use effective soil conservation options in Ethiopia (Adimassu *et al.*, 2013; Tefera & Sterk, 2010).

The findings with respect to land ownership indicated that the majority (99%) of the farmers owned their land holdings (Table 5.7). This finding with regard to land ownership is consistent with similar results reported by Deininger, *et al.*, (2008); Fenske (2011); Gavian & Fafchamps (1996); Jayne *et al.*, (2003), across different parts of Africa and Okeke *et al.*, (2013); Okoye *et al.*, (2008), in Nigeria. Thus, the finding is conformity with the idea that traditionally, land ownership in this area is basically communal. Therefore, this may encourage farmers to effectively plan and implement relatively permanent soil conservation structures on their farm plots, and hence, farmers' reasons for cultivating hillslopes whereas flatlands exist.

Farm holdings in the study region can generally be regarded as small (Table 5.9), and based on Shaib *et al.*, (1997), farm holdings classification scale, namely; small scale = 0.10-5.99ha; medium scale 6-9.99ha, and large-scale cultivation 10ha and above. Land fragmentation through an effort to allocate land to every heir of the family. In addition, to the farm sites, most of which are located on hill slopes and farmers have to work hard to locate spaces where the soil is deep were the farmers' reasons for small farm size. The small farm size was also confirmed through field observation and oral interviews with farmers. Thus, the small farm size is reflective of the fact that the respondents were basically peasant farmers operating on small farm size. This finding is consistent with the previous study conducted by Place (2009); Yusuf & Ray (2011), in northeastern Nigeria, where land holding in the region were reported to be generally small. Thus, the finding is conformity with the idea that the African farmers are generally peasant farmers working on small hectares of land (Tittonell *et al.*, 2006).

However, others previous studies carried out in the northwestern and north central parts of Nigeria by Essiet (1990); Ogunwole *et al.*, (2002); Onyewotu *et al.*, (2003), have revealed inconsistent findings, where the mean hectares of cultivated fields per farmer were indicated to be in the range of a medium to large scale. This implies that farmers from the northwestern and north central zone of Nigeria cultivate relatively larger hectares of land than their counterparts in the northeastern region of Nigeria. Thus, the practice of soil conservation measures to combat soil erosion and soil fertility depletion may more likely be impacted negatively due to the farmers' farm sizes.

The result with regard to the number of farm plot worked by farmers in the study region shows that the majority of the farmers (77.3%), worked on more than 5 farm plots with the distances between farm from their homestead greater than 3km (54.5%) (Table 5.10) and (Table 5.11). This result is consistent with those reported by Tesfaye *et*

al., (2014); Wolka *et al.*, (2013); Zegeye *et al.*, (2010), in Ethiopia and by other studies in Nigeria Ogunwale *et al.*, (2002); Thapa & Yila (2012); Yusuf & Ray (2011), where farmers were reported to work on 5 farms and travelled a distances of about 5kms from their homestead to operate their farms. Hence, adoption of effective soil conservation measures to halt soil erosion and improve soil fertility will be impacted negatively.

Most farmers during in-depth interviewed, explain that they worked on more than 10 farm plots that are located at different or scattered places and the distance between farms plots are far away from their homestead. The farmers further explained that, they do not often have enough chance to observe their farm plots daily or even for weeks. Consequently, the ignored cultivated plots could be eroded by a sudden runoff if the cutoff drain or other soil conservation measures are destroyed by run off at the time of high intensity of rainfall. During the field survey, it was observed that erosion has impacted more on small and distant farm plots far away from home. Hence, the reason for the severe nature of on-farm soil erosion in the study.

The results on farmers farming experience revealed that the majority of the farmers had a long period of farming experiences (Table 5.13). This implies that the farmers might be conversant with soil erosion problems and constraints to improved conservation measures. This was confirmed through an oral interview with the farmers. This result is consistent with the findings of the previous studies which revealed that most traditional African farmers have long years of farming experiences (Genene & Wagayehu, 2010; Ndiaye & Sofranko, 1994). Another previous study indicates that farming experience has a positive and significant influence on the adoption of soil conservation measures (Rushemuka *et al.*, 2014). Kiome & Stocking (1995), urged that long period of farming experiences increases the farmers' probability of uptake of soil conservation technologies because the experienced farmers have better knowledge and

information on crop and soil conservation measures. This concurred with the findings earlier reported by Green & Heffernan (1987); Willock *et al.*, (1999), that, long period of farming experiences increases farmers level of acceptance of new ideas as a means of overcoming their production constraints and hence, increased production. Hence, the farmers' reason for cultivating hillslopes while flatlands provided by nature exist.

Summarizing, the findings indicates that the majority of farmers in the study region are of middle-aged, male and married. A significant proportion of them are literate, they owned their landholdings and have long years of farming experience. Hence, reasons for cultivating hillslopes whereas flatland exists in the study region. However, they have, large family size members, small and scattered farm sizes, absent of off-farm and inadequate farm incomes.

6.3 Farmers' perception about soil erosion by water and their preferences for cultivating hill slopes in the study region

Farmer perceptions of soil erosion in the form of water erosion and its consequences are the most significant social factors that determine their degree of understanding of soil erosion and its effects (Adimassu *et al.*, 2013; Kerr & Pender, 2005; Moges & Holden, 2007). In addition, the perceptions influence the level of support and investment by the farmers put towards solving soil erosion and fertility depletion problems by adopting alternatives and conservation practices (Mendesil, *et al.*, 2007; Moges & Holden, 2007; Odendo *et al.*, 2010). Thus, knowledge of these aspects is fundamental to understanding the knowledge levels of farmers. Researchers and agricultural extension personnel to refine their research can use this information and conservation practices to better respond to the needs of farmers (Bewket & Sterk, 2002; Gruver & Weil, 2007).

To gauge farmers' perception of soil erosion problems, farmers' were asked whether they are aware and perceived soil erosion by water as a problem in their farm plots. The results show that farmers are, in general, well aware and reported the problem of water erosion on their farms (Table 5.15). This proportion of farmers (91.9%) indicates a generally high level of awareness and perception of the water erosion problem in the study area. This finding is in agreement with the earlier results reported by Bewket (2011); Okoba & De Graaff (2005); Yusuf & Ray (2011), across the different African countries and Nigeria, where a positive association between farmers' perceptions of soil erosion as a problem versus their investments in soil conservation was reported.

Most of the farmers interviewed confirmed the high degrees of awareness and perception of water erosion as a problem. For example, one farmer expressed the opinion that neither public nor private institutions had given appropriate attention to soil conservation. In addition, some farmers recognized that soil from their cultivated fields is reducing in depth through time and the numbers of rills and stones in their farmlands have been increasing over time. Of course, farmers are acquainted with soil erosion from observations of their surroundings, where, farmlands have been left uncultivated and became rock outcrops with un-crossable gullies, and accumulated years of farming experiences. This observation, explains the general awareness among farmers of soil erosion problems.

Field characteristics and the nature of the topography are the major factors that influenced farmers land use types and the type of soil erosion (Bewket, 2003). With this background; the field characteristics of the sampled farmers are identified in terms of their slopes. The result of the survey indicated in Table 5.16, revealed that the majority of the farmers have their farmlands either located on the steep or gentle slopes, a place where most soil erosion is taking place and only a small percentage farmed in flatland areas. A situation Ovuka & Ekbom (1999), described to be symptoms of a lack of

awareness of soil erosion in their studies of farmers resources level, soil properties, and productivity in Kenya's central highland. But, in the present study the farmers in the study region are aware of the erosion problems prone to such areas, given their evidence of on-farm erosion causes and indicators (Table 5.20), and (Table 5.22). In addition, most of the farmers interviewed indicated that their consideration is not erosion, but weed, grazing animals, and inheritance, which outweigh erosion problems.

On farmers' preferences for cultivating hillslopes while flatlands exist, the finding revealed that the majority of farmers forming 95.5% prefer to cultivate the hill slope, not because of the shortages of flat land areas, but because of less crop destruction by animals, less weed invasion, and historical reasons (Table 5.17). During the transect surveyed and oral interviews, most farmers interviewed confirmed the above findings, when some stated that, they are aware of soil erosion, but they are forced to intensify cultivation in hill slopes areas to produce more food crops for their basic livelihood because of weeds, grazing animals, and inheritance. This result, therefore, gives a clear picture of the perception of soil erosion in the research region as perceived by the respondents.

Summarizing, the findings indicate that all of the interviewed farmers are well aware and the majority perceived soil erosion by water as a problem constraining crop production in their farm plots. The results also indicate that most of the farmers had their farmlands either located on the steep or gentle slopes, a place where most soil erosion is taking place. According to the farmers, they cultivate hill slope, not because of the shortages of flatland areas, but because their consideration is not erosion but, weeds, and grazing animals which outweigh erosion problems.

6.4 Farmers' perception of the causes, indicators, effects and consequences of soil erosion in the study region

This section discusses the farmers' perceptions about the causes, indicators, effects and consequences of soil erosion under agricultural lands. To explore farmers' perception about the causes and indicators of soil erosion problems, farmers' were asked to list the causes of soil erosion, methods of identifying soil erosion and when.

As indicated in table 5.20, high-intensity rainfall, types of soil and erodibility, insufficient and delay fertilizer were the major reasons listed by farmers for the increase in water erosion. This means that the majority of the farmers are well aware of the causes of soil erosion, but they do not see it as an individual problem on their farms. An important finding of the study is that not all the farmers consider slope steepness of cultivated farms to be a major cause of erosion. However, the farmers can be said to have a better knowledge of soil erosion problems, as is seen in their ability to perceive insufficient and a delay in fertilizer (soil fertility depletion related factor) as a cause of soil erosion. This result is consistent with those reported by Moges & Holden (2007); Okoba & De Graaff (2005), in Ethiopia and by other studies in Nigeria Essiet (1990); Hoffmann *et al.*, (2001); Thapa & Yila (2012), which identified high intensity rainfall, deforestation, cultivation of marginal areas and inappropriate soil conservation as the reasons listed by farmers for the increase in water erosion. In addition, this finding clearly provides support for the conclusion of Assefa & Hans-Rudolf (2016); Odendo *et al.*, (2010); Okoba & Sterk (2006), who indicated that farmers often see a relationship between erosion and crop yields, but are often reluctant to accept soil erosion an individual problem on their own farms. Thus, the finding is conformity with the idea soil erosion under agricultural fields is caused by factors beyond the farmer's control.

Indeed, transect surveys in the entire region confirmed that rainfall was more intense than in the neighboring regions, and soil conservation measures were properly designed and most of them are not damaged. Also, as recognized from in-depth interviewed farmers perceived soil erosion to be severe on farm plots at rainy or summer season locally called “*damuna*”, this shows that the major cause of soil erosion in the study region is water erosion.

The surveyed households consider erosion to be severe mostly when visible signs-rills and gullies appeared on their cultivated fields 48.8%, and when there are changes in soil colour 21.1% (Table 5.22). These mean that above 86% of the farmers sampled in the research region; look for visual signs on their cultivated fields as the main indicators of soil erosion. Surprisingly, only, 1.8% of the respondents perceived sheet erosion as a problem, which has been estimated in the literature to contribute to soil up to 30% of actual soil loss (Govers, 1991). The reasons for such a perception could partly be explained by high-intensity rainfall and the cultivation of most erosion-prone areas in the study region. This finding is consistent with the findings of the previous study, which revealed that development of rills and gullies, exposure of the roots, change in soil colour, increased in the level of farmland stoniness were the major erosion indicators listed by farmers (Amsalu & Graaff, 2006; Gebremedhin & Swinton, 2003). Thus, the finding is in conformity with the idea that most farmers, particularly the untrained ones identified soil erosion on cultivated lands by visible signs and often disagree with the scientific evaluation of the erosion condition by professional soil scientist and agricultural extension agents.

From table 5.23, it can be seen that 55.1% of the farmers forming the majority, reported that their farmland have been reduced in sizes by erosion, 12.3% and 15.1%, indicated that their cultivated fields were reduced in size by being submerged, and

require high input and management respectively. This suggests that the majority of the farmers perceived a reduction of arable land as the principal effect of soil erosion in the study area. This finding is not consistent with the previous study reported across different parts of Nigeria (Akinagbe & Umukoro, 2011; Junge *et al.*, 2009; Ogunwale *et al.*, 2002), and in other African countries (Nyssen *et al.*, 2009; Odendo *et al.*, 2010; Tefera & Sterk, 2010; Wolka *et al.*, 2013), which showed that farmers cited loss in soil fertility as the major effect of soil erosion. The high intensity of rainfall, and increased agricultural activities on sloppy areas could be the main reasons for such a perception. Informal discussion with farmers also confirmed their general focused on rainfall and water as a limiting factor for agricultural lands. Similarly, based on field observation, and oral interview with local extension agents, the severity of soil erosion is high in the study region.

On whether erosion has more consequences on the slopes of farmlands than flatland farmlands, the majority of farmers' exhibit ignorant, only a few are aware. Although, a relatively larger proportion of the farmers are not aware, these farmers still were able to decipher that a reduction in crop yield is also a consequence of the effects of soil erosion (Table 5.24). The main reasons for such a difference in perception are the farmers' long years of farming experiences and the practice of good and effective soil conservation measures. This finding clearly provides support for the conclusion of Kerr & Pender (2005); Teshome *et al.*, (2013), who indicated that, although farmers are aware of the added effort and cost of controlling soil erosion, the damage caused by erosion often goes unnoticed. The above studies were inspired by the work of Rickson *et al.*, (1987), who had earlier state that, due to the insidious nature of the pervasiveness of soil erosion, farmers misperceive either or both the existence or extent of erosion on their farmlands.

Summarizing, the results show that the majority of the farmers are well aware of the factors associated with water erosion, but are reluctant to accept that erosion is an individual problem on their farms. The surveyed households perceive soil erosion to be severe mostly when visible signs-rill and gullies appeared on their cultivated plots and when there is a change in soil colour. Farmers perceived the effects of soil erosion on the farms, mostly by visible signs of reduced farmland sizes, by submerged and drop in yields. The farmers are well aware of the erosion consequences on slopes farmlands than flatland farmlands, but they do not see it as a threat because of the advantages they derive outweigh erosion problems. This is the reason why farmers' in the study area cultivate hill slope areas whereas flatland areas exist.

6.5 Farmers' perception of the trend water erosion

In assessing how farmers perceived the trend of water erosion in the research region, farmers were asked how they perceived the trend of water erosion over the last 10 years (1= increasing, 2= no change, 3 = decreasing) (Table 5.25).

The results indicate that two-thirds (80.2%) of the sampled respondents had a high level of perception that the trend of water erosion is increasing (Table 5.25). This result with regard to trends of water erosion followed up similar results obtained by Vigiak *et al.*, (2005), in Tanzania, Rushemuka *et al.*, (2014), in Rwanda, Adimassu *et al.*, (2013); Tefera and Sterk (2010), in Ethiopia, and are consistent with studies elsewhere in Nigeria (Okoye *et al.*, 2008; Oluwasola & Alimi, 2008; Yila & Thapa, 2008).

Farmers' were also asked about the factors that stimulated the changes in the trend of water erosion. High rainfall intensity, deforestation, bush burning, cultivation of marginal areas, and inappropriate soil conservation techniques were farmers' reasons for the increased in the trend of water erosion over the years. On the other hand, the reasons mentioned by the farmers that reported no change, and decreased in the trend of water erosion over the years were the used of external inputs for soil erosion and soil

fertility replenishment and of soil conservation practices to restore and maintain soil fertility. However, field observations, oral interviews with farmers and local extension agents confirmed the increasing trend of water erosion. Hence, there is a generally high degree of awareness and perceptual experienced about the trend of water erosion in the study region. Hence, farmers reason for cultivating hillslope whereas flatlands exist.

Summarizing, the results indicated that above two-thirds (80.2%) of the sampled respondents, had a high level of perception that the trend of water erosion is increasing. High rainfall intensity, deforestation, bush burning, cultivation of marginal areas, and inappropriate soil conservation techniques were farmers' reasons for the increased in the trend of water erosion over the years.

6.6 Farmers' soil conservation measures

Soil conservation measures refer to efforts made by farmers to control water erosion and improve soil fertility (Adimassu *et al.*, 2014; Briggs, 2005; Cobo *et al.*, 2009). They can be broadly categorized into three areas according to the type of soil degradation: 1. Water erosion control, this includes measures such as soil or stone bunds, grass strips and contour vegetation barriers that control both run-off and run-on and harvest rainwater (Amsalu & Graaff, 2006; Anley *et al.*, 2007; Bewket, 2007). 2. Soil fertility control measures, which refer to practices such as the application of organic amendments or inorganic fertilizers that replenish the fertility of the soil; 3. Mixed control measures, encompassing practices such as alley farming and other Agroforestry systems that retain soil nutrients and prevent water erosion through the integration of trees, shrubs, and crops (Anjichi *et al.*, 2007; Chen *et al.*, 2007; D'Emden *et al.*, 2008).

Thus, this section discusses the results in three successive sections. The first segment discusses farmers' perception of soil erosion and fertility control measures, agricultural systems and the farmers' types of soil erosion control and soil fertility measures

practiced. The second section discusses farmers' perceptions about the effectiveness of the existing traditional soil conservation methods practiced in the study region. The third section covers the farmers' perception about the trend of soil fertility depletion over the last ten years in the study region.

6.6.1 Farmers' perception of soil erosion

Water erosion control measures are soil conservation practices that control run-off or run-on (Dalton *et al.*, 2014; de Graaff *et al.*, 2010). Traditionally, farmers begin investing in soil conservation when they observe water erosion and depletion of soil fertility (Gebremedhin & Swinton, 2003; Haregeweyn *et al.*, 2015; Junge *et al.*, 2009). Thus, in assessing how farmers perceived soil erosion control on their individual farmlands during the normal cropping year, farmers were asked whether water erosion could be a control on their land (1 = yes, 2= no). As indicated in table 5.26, the majority of the farmers 89% believed that soil erosion could be halt on their farms. This suggests the presence of a high-level perception among farmers that, soil erosion could be control in the research region. Similar findings by Amsalu and Graaff (2006); Anley *et al.*, (2007), were reported, where a high-level perception among farmers of soil erosion controls was found. Another previous study by Moges & Holden, (2007), indicates a negative association between farmer perceptions and their investments in soil erosion control. Thus, the finding of this study is in conformity with the thrust that farmers often believed that erosion could be halted and often perceived soil conservation measures as an effective option for a successful increase in crop yields, soil water retention, and increase land value. Farmers long years of farming experiences, knowledge and techniques of better erosion control measures were the reason for the high perception of soil erosion control in the research region. Hence, farmers' reason for cultivating hill slope areas, while flat lands provided by nature exists.

On whether farmers adopt water erosion control measures in their field, the results revealed that a greater proportion of the farmers in the study region practice some soil conservation measures for the control of water erosion (Table 5.27). However, the farmers' level of adoption of soil erosion control measures is low (Table 5.28).

6.6.2 Farmers' perception of soil fertility measures

Soil fertility refers to the availability of plant nutrients and soil organic matter in the soil (Kagabo *et al.*, 2013; Powlson *et al.*, 2011). Soil fertility decline occurs when the use of soil nutrients exceeds their replenishment. Soil erosion results in the depletion of nutrients and loss of soil organic matter (Wickama, *et al.*, 2015). Soil degradation can be amended through soil fertility control practices. Soil fertility control measures are soil conservation practices such as the application of organic amendments and inorganic fertilizers that replenish the fertility of the soil (Thierfelder *et al.*, 2013; Vancampenhout *et al.*, 2006; Vigiak *et al.*, 2005). Both organic and inorganic fertilizers are important for protecting the soil and for increasing crop yields.

In appraising farmers' perception of soil fertility, farmers' were asked whether soil fertility depletion is perceived as a problem (1 =Yes, 2 = No) and whether soil fertility depletion could be controlled (1 =Yes, 2 = No). The majority (83.8%) of farmers reported that soil fertility depletion was a problem on their farms (Table 5.29), and soil fertility depletion could be controlled in the research region. This high proportion of respondents that perceived soil fertility depletion as a problem emphasizes the direct effect of soil erosion on the farmers' perception of soil fertility depletion and is consistent with similar results reported in different parts of Nigeria Barungi *et al.*, (2013); Hoffmann *et al.*, (2001); Junge *et al.*, (2009), and other African countries (De Graaff *et al.*, 2008; Moges & Holden, 2007; Nkamleu & Manyong, 2005; Nyssen *et al.*, 2009). Decrease in crop yield, increase usage and cost of external inputs (e.g labour,

chemical fertilizer) were the farmers' reasons and this was confirmed through field observation, oral interview with traditional community agricultural chiefs (locally titled *Sarkin Noma*) and local extension agents in the study region.

On whether farmers adopt soil fertility measures in their field, the results revealed that a greater proportion of the farmers in the study region employed the practices of soil fertility measures on their individual farms (Table 5.30). Implying, a large percentage of the total agricultural area in the study region are treated with soil fertility control measures. The result with respect to the level of adoption of soil fertility measures reveals a medium level in the research region (Table 5.31). This finding highlights the importance of soil fertility control and the fact that implementing such measures is a common cultural practice for most farmers. These measures are also easier to apply compared to water erosion control measures and generally provide a faster return. In addition, as noted by Adimassu *et al.*, (2013), nutrient application to crops is an annual practice with annual costs and gains, whereas investments in erosion control measures are associated with long-term gains.

6.6.3 Agricultural systems

The result of this study indicates that the hoe, which represents 79.4% of the responses, mainly does cultivation activity in the region (Table 5.32). This means that many farmers in the study region have actually embraced the use of the hoe. Small farm sizes, site, and the ease with which they can use to cultivate their plots were the farmers' reasons for higher usage of the hoe in the study region, and this was confirmed through a field observation oral interview with the farmers and local extension agents.

The results of this survey further revealed that the farmers grow a variety of food crops, with guinea corn, maize, and yam as the major food crop (Table 5.33). Information gathered from the farmers during the oral-interview revealed that sources of

food and income were the farmers' reasons for cultivating the varieties of crops. Thus, the finding is conformity with the idea that the farming systems and farming practices in Nigeria are characteristic of subsistence agriculture.

From table 5.35, the finding with respect to common crop combinations indicates that all the farmers in the research region practiced the cultivation of different types of crop combinations in their individual fields. With the majority practicing the combination of guinea corn with maize and beans, yam with vegetable and groundnut, and guinea corn with beans. An important finding of the study is that legume crops are virtually integrated into all intercropping types. Intercropping particularly which utilizes legumes helps to reduce soil erosion risk and maintain soil fertility (Kabubo-Mariara *et al.*, 2006; Kairis *et al.*, 2013). The finding of this survey is consistent with the finding of the previous studies, including those of Barungi *et al.*, (2013); Bronick & Lal, (2005); Hoffmann *et al.*, (2001), which revealed that farmers were found to practice the cultivation of different types of crop combinations on their individual fields as a deliberate measure to maintain soil fertility. This also clearly provides support for the conclusion of Kassie *et al.*, (2013), that, intercropping of cereals such as maize, (*Zea mays*), sorghum (*Sorghum bicolor*) or millet (*pennisetum glaucum*) with herbaceous grain legumes or root and tuber crops with other annual crops helps improve soil productivity and crop yields. This finding is also in conformity with the idea that intercropping generally contributes to erosion control (Hurni 1988). Thus, the practice of intercropping systems, suggests the farmers' high level of awareness of soil erosion problems, and the needs for soil fertility enhancements in the research region. Hence, farmers' reason for cultivating hill slopes, while, there are flatland areas.

6.6.4 Types of soil erosion control measures practiced in the study region

The farmers in the research region employed the practice of different types of water erosion control techniques (Table 5.36). The major one according to the farmers are Ploughing across the contour, construction of bunds, construction of ridges, and waterways. However, despite their wide fame, terracing and mulching were only adopted by a small percentage of the sampled farmers, hence an important finding of the study. The greater percentage of households that had constructed different types of water erosion control measures in the research region is due to their knowledge, farms located in areas of high rainfall and steep topography. Thus, the use of different types of soil erosion measures of the farmers in the research region suggest the farmers' good knowledge and measures of combating soil erosion on their individual farms. Hence, farmers' reason for cultivating hill slopes while there are flatland areas in the research region.

6.6.5 Types of soil fertility enhancement measures practiced in the study region

The results in table 5.37 revealed that farmers in the research region have the knowledge, and are using different conservation measures to enhance the fertility status of their agricultural lands. Use of compost and mulching, intercropping, and use of farmyard manure, were the most widely used traditional soil fertility enhancement measures in the research region. Based on interviews with farmers, accessibility and better availability of manure as a result of large livestock populations contribute to this high percentage of respondents applying soil fertility measures. This result is consistent with the findings of Adegbedi *et al.*, (2004); Bell *et al.*, (2014); Cobo *et al.*, (2009), except that, in the present study all the farmers sampled used at least a conservation measure to enhance the fertility status of their agricultural lands. A condition that indicates the farmers' high-level awareness of soil fertility depletion, and hence, farmers' reason for cultivating hill slope areas, while the flatlands exist.

A relatively very few farmer used inorganic fertilizer (chemical fertilizer). Based on the information gathered during the in-depth interviews, increasing cost of fertilizers, lack of access and/or untimely distribution of the fertilizer were the farmers' reasons. While, yellowing of the crops, reduced crop yields, and poor crop performance were the farmers' indicators of soil fertility depletion in their individual farms.

Summarizing, the findings revealed that there was a high perception among farmers that, soil erosion and fertility depletion could be control in the research region. In addition, soil fertility depletion is seen as a problem constraining crop production in the research region. However, despite their perceptions of soil erosion and fertility measures, the use of and level of adoption in soil erosion and fertility depletion was below the optimum level for successful control. Cultivation activities are mainly done with hoes, and the farmers cultivate varieties of food crops, with guinea corn/maize, and yam as the major food crop cultivated. The farmers also, employed the practiced of cultivating (combining) different types of crop in their individual fields to combat erosion menaces and soil fertility depletion on the individual fields. The results further revealed that the farmers employed the practice of different types of water erosion and fertility depletion control measures in their individual fields. With the Ploughing across the contour, construction of bunds, construction of ridges, and waterways as major water erosion measures and the use of compost and mulching, intercropping, and use of farmyard manure as the most widely used traditional soil fertility enhancement measures in the research region. Thus, the used of different types of soil erosion and fertility measures by the farmers in the research region suggest the farmers good knowledge and measures of combating soil erosion and fertility depletion on their individual farms. Hence, farmers' reason for cultivating slopes while; there are flatland areas in the research region.

6.7 Perceived effectiveness of the different types of soil erosion and fertility control measures practiced in the study region

From table 5.39, the results indicated that farmers in study region have recognized the efficiencies of all the different types of soil erosion control measures, but perceived ploughing across the contour, construction of bunds, construction of ridges and waterways as the most effective measures capable of preventing soil erosion phenomenon on their crop fields. Similar findings have been reported by Adimassu *et al.*, (2014); Amsalu and Graaff (2006); Vancampenhout *et al.*, (2006), where they revealed that, farmers used a range of practices for soil erosion control and fertility management, but, contour plowing, drainage ditches, and stone terraces/bunds were they preferred soil conservation measures in mountainous regions where agriculture is practiced.

Indeed, the transect walk in the entire region confirmed that ploughing across the contour, construction of bunds, construction of ridges and waterways technologies were the most widely and properly constructed structures in the research region. Surprisingly, a relatively significant proportion of farmers as effective perceived mulching and terracing that were least perceived as the major types of soil erosion control measures. Therefore, the ability of the farmers to recognize as effective all the different types of soil erosion control measures suggests, the farmers' high level of awareness of erosion control alternatives and the reason for cultivating hill slopes while flatlands exist.

From table 5.40 the results indicated that farmers in the research region have a wealth of knowledge and perceived all the forms of soil conservation alternatives for soil fertility enrichments as effective. However, as the most effective forms of soil fertility enhancement measures practiced in the study region, the use of inorganic fertilizer, and farmyard manure were perceived. This means that farmers in the research

region have a wealth of knowledge and experiences about the practicality and efficiency of all the soil fertility alternatives practiced. The reasons could be, due to their long years of farming experiences and cultivation of hill slope areas. Moreover, through informal interviews with the traditional community agricultural chiefs (locally titled *Sarkin Noma*), it was discovered that extension agents in the communities are mainly promoting soil fertility control measures, such as composting, and rarely inform farmers of the importance of investing in water erosion control measures. Hence, reasons for cultivating hill slope while, flatlands provided by nature exist.

Summarizing, the results revealed that, farmers perceived ploughing across the contour, construction of bunds, construction of ridges and waterways as the most effective measures capable of preventing soil erosion phenomenon on their crop fields. Similarly, the farmers perceived all the forms of soil conservation alternatives for soil fertility amendments as effective, with the use of inorganic fertilizer, and farmyard manure perceived as most effective.

6.8 Farmers' perception of the trend of soil fertility depletion

In appraising farmers' perception on the status of the current trend of soil fertility depletion in the study region, farmers were asked how they perceived the trend of soil fertility over the last 10 years (1 = increasing, 2= no change, 3= decreasing).

The majority (72.8%) of farmers reported soil fertility decreasing over the last decade (Table 5.41). Based on the information collected from the farmers interviewed, the main reasons for the perceived decreased in soil fertility for the major portion of the study region are the farmers' perception of soil fertility as a limiting factor for crop production rather than water erosion.

Farmers' were also asked about the factors that stimulated the changes in the trend of soil fertility. Complete removals of crop residues were farmers' major reason for the

decreased in the trend of soil fertility over the years. Complete removal of crop residues can cause a large drain on the nutrient stock and the decline in soil fertility. Field observation and oral interview with extension agents revealed that crop residues are systematically used for livestock's feed during the shortage of grass and also livestock are fed on crop residues as part of the grazing pattern where they are left to roam freely on cultivated land immediately after harvest. Farmers, however, revealed that the use of crop residues both for livestock feed and cooking could facilitate soil nutrient depletion. Increasing use of external inputs for soil fertility replenishment and of soil conservation practices to restore and maintain soil fertility were the farmers reasons for the no change, and increasing in the trend of soil fertility over the decade. However, field observations, oral interviews with the traditional community agricultural chiefs (locally titled *Sarkin Noma*), and local extension agents confirmed the decreasing trend of soil fertility over the decade. Hence, there is a generally high degree of awareness among farmers in the study region about the trend of soil fertility.

Summarizing, the finding revealed that the majority of farmers reported soil fertility decreasing over the last decade. Complete removals of crop residues were farmers' major reason for the decreased in the trend of soil fertility over the years

6.9 Farmers' adoption of soil conservation measures in the study region

This section discusses farmer' perception regarding their adoption of soil conservation measures to control soil erosion and fertility depletion. The first segment discusses the farmers' participation in local organizations and the types of services needed to control soil erosion and fertility depletion in their farm. The second section covers the farmers' perception about the sufficiency, timely, and frequency of services provided by extension agents to control soil erosion and fertility depletion in the study region. The third discusses the relationship between farmers' adoption of soil conservation measures and their perception of water erosion and soil fertility depletion as problems. Lastly, the

fourth phase covers the farmers' perceived trend of water erosion and soil fertility depletion and their level of adoption of soil conservation measures.

6.10 Farmers' participation in local organizations and the types of services needed to control soil erosion and fertility depletion on their farm

Land users association at the grassroots level plays a major role in dealing with soil erosion and fertility depletion problems. Local organizations with appropriate support and encouragement could facilitate participatory development and help to address soil erosion and fertility depletion problems. Table 5.42 shows farmers' responses with respect to their participation in local farmers association in the study region. From the table, the results showed that the majority of the farmers 54% are actually organized in the local association. Positive attitude towards conservation measures and with government-initiated conservation measures were the farmers' reasons for participating. This finding is consistent with the previous study, which indicated that farmers in most African traditional societies Nigeria inclusive are organized into local association, particularly, by age grades to practice soil conservation measures. In addition, a significant relation between farmers' association in local organization and soil conservation practices on their farmland were found. Thus, the finding is conformity with the idea that farmers who are organized in the local association are more likely to practice soil conservation measures on the fields than the farmers who are reluctant to participate in the local association. Hence, farmers reason for cultivating hillslopes whereas flatlands areas exist.

The results on table 5.43 showed that the majority of farmers 98.9% needed assistances to control soil erosion and fertility depletion on their farms. Agricultural loan, affordable and timely distribution of chemical fertilizer was the types of assistance much needed to control soil erosion and fertility depletion by the farmers. This was confirmed through an oral interview with the traditional community agricultural chiefs

(locally titled *Sarkin Noma*) and the local extension agents in the study region. This finding is in conformity with the impression that the farming system and farming practice in Nigeria are characteristically of the subsistence type. This means that the majorities of the farmers are subsistence-oriented and could not afford optimum replacement of lost soil quality.

Summarizing, the results revealed that the majority of the farmers 54% are actually organized in the local association. Hence, the farmers reason for cultivating hillslopes whereas flatlands areas exist. However, most, 98.9% of the sampled farmers needed assistances to control soil erosion and fertility depletion on their farms.

6.11 Farmers' perception about the sufficiency, timely, and frequency of services provided by extension agents to control soil erosion and fertility depletion in the study region

Access to extension agents is expected to provide information, which could play a significant role in soil erosion control and soil fertility enhancements. In another word, it will facilitate and encourages the farmers to practice soil conservation measures. The sampled farmers were asked about their access to extension agents. The majority indicated that they do not have access to extension agents (Table 5.45), which suggests there were no effective extension services provided to them during the year under review. Weak organizational structure, inadequate supervision, inadequately trained staff, and lack of efficient accessibility (terrain nature) to reach farmers effectively were the farmers' reasons. This was confirmed through an oral interview with the farmers and the traditional community agricultural chiefs (locally titled *Sarkin Noma*). For example, most of the farmers expressed the opinion that extension agents hardly visit them in a year. This implies that extension agent's visits were infrequent, irregular, and insufficient in the research region. This finding is consistent with the previous studies,

which indicated that extension agents one to three times per year often visited farmers (Bewket, 2007). Therefore the farmers used of traditional soil conservation measures to control erosion and soil fertility depletion was instrumental to the continuous and well-sustained crop productivity in the research region. Hence, farmers' reason for cultivating slopes while flatlands exist.

Though, farmers might have good knowledge of the existence and level of soil erosion, in terms of its causes, extents and consequences on their farmlands. Yet, extension services are required to stimulate or enhance farmers' willingness to accept and adopt effective soil conservation measures. The sampled farmers were asked about the different types of services that have been given to them by extension agents. The majority of the farmers (90.3%) indicated improved varieties of crops, and soil fertility amendment (Table 5.46). This finding is consistent with the results of previous studies including those of Adimassu *et al.*, (2014); Amsalu and Graaff (2006); Yusuf & Ray (2011), where they indicated that extension agents in most African countries are mainly promoting soil fertility control measures, such as composting, and rarely inform farmers of the importance of investing in water erosion control measures. However, based on the oral information collected from the farmers and agricultural chiefs, water erosion was perceived as a limiting factor for crop production rather than soil fertility.

Regarding the level of satisfaction of extension services provided them to practice soil conservation measures. All the farmers indicated that they were not satisfied (Table 4.48). Implying extension services, which was to facilitate and encourage the farmers to practice soil conservation measures were not provided to farmers during the years under review. Weak organizational structure, inadequate supervision, inadequately trained staff, and lack of efficient accessibility (terrain nature) to reach farmers effectively were the farmers' reasons. This finding was further confirmed through an oral interview with

the traditional community agricultural chiefs (locally titled *Sarkin Noma*) and some farmers, where some expressed the opinion that the services provided by the extension agents were insufficient, irregular and infrequent. In addition, the finding is conformity with the idea that in most African countries, the government often establishes agencies, institutions and creates programs to provide services to improve agricultural productivity through effective soil conservation measures, but many of this initiative and services were poorly conceived, implemented and only provide lip services.

Summarizing, the findings revealed that the majority of the farmers indicated that they do not have access to extension agents, which implies extension agent's visits were infrequent and irregular in the research region. A greater proportion of the farmers (90.3%) indicated improved varieties of crops, and soil fertility amendment as the major types of services given to them. However, all the farmers indicated that they were not satisfied were the extension services given them. Implying extension services, which was to facilitate and encourage the farmers to practice soil conservation measures were insufficient, irregular and infrequent provided.

6.12 The relationship between farmers' adoption of soil conservation measures and their perception of water erosion and fertility depletion as a problem

The finding with respect to the relationship between farmers' adoption of soil conservation measures and their perception of water erosion and fertility depletion as a problem revealed that the farmers who perceive water erosion as a problem on their land do not adopt significantly ($p < 0.05$) more than do farmers who do not perceive water erosion as a problem (Table 5.49). During the field investigation, lack of available technologies, access to extension agents and services, coupled with a lack of financial assistance were the reasons why farmers invested little in soil erosion control measures. Studies from other parts of the country, such as those of Dimelu *et al.*, (2013); Thapa &

Yila (2012), confirm the small adoption of soil erosion control measures by Nigerian farmers, the lowest among most countries in sub-Saharan Africa (Junge *et al.*, 2008).

However, farmers who perceive soil fertility depletion as a problem on their land do adopt significantly ($p < 0.05$) more than do farmers who do not perceive fertility depletion as a problem. Based on interviews with farmers, accessibility and better availability of manure as a result of large livestock populations contribute to this high percentage of respondents applying soil fertility measures. Moreover, through informal interviews, it was also discovered that extension agents in the communities are mainly promoting soil fertility control measures, such as composting, and rarely inform farmers of the importance of adopting water erosion control measures.

Summarizing, The finding with respect to the relationship between farmers' adoption of soil conservation measures and their perception of water erosion and fertility depletion as a problem revealed that the farmers who perceive water erosion as a problem on their land do not adopt significantly ($p < 0.05$) more than do farmers who do not perceive water erosion as a problem (Table 5.49). However, farmers who perceive soil fertility depletion as a problem on their land do adopt significantly ($p < 0.05$) more than do farmers who do not perceive fertility depletion as a problem. Based on interviews with farmers, accessibility and better availability of manure as a result of large livestock populations contribute to this high percentage of respondents applying soil fertility measures

6.13 Farmers' perceived trend of water erosion and soil fertility depletion and their level of adoption of soil conservation measures

Table 5.50 presents the farmers' perceived trend of water erosion and soil fertility depletion versus their level of adoption of soil conservations measures. The results reveal that most farmers in the study area perceive increasing water erosion and declining soil fertility as an increasing problem, however, this perception does not significantly influence their decisions to increase the level of adoption in soil conservation or water erosion and soil fertility control measures.

Therefore, why do farmers fail to increase their level of adoption in soil conservation in the study region? From studies elsewhere around the globe, we know that there are other socioeconomic, biophysical, institutional and technological factors that must be considered, including the effects of crises that influence farmers' level of adoption (Chianu & Tsujii, 2004; Deng *et al.*, 2006; Illukpitiya & Gopalakrishnan, 2004; Kassie *et al.*, 2013; Meseret, 2014; Tiwari *et al.*, 2008; Tosakana *et al.*, 2010). These are often farmer, institution, and site-specific factors. Although the study investigated household level factors, further research regarding the factors affecting the soil conversation decisions of farmers in the study area is needed. This research is imperative to provide valuable insights into why farmers use conservation practices and how they adjust and level of adoption in these practices. Moreover, given the significant spatial variations in the country's physical environments, socioeconomic circumstances, and cultural practices, such local-scale studies are critical to the design of regionally and nationally appropriate soil conservation and economic development strategies in Nigeria.

Summarizing, the results with respect to the trend of water erosion and fertility depletion reveal that most farmers in the study area perceive increasing water erosion and declining soil fertility as an increasing problem, however, this perception does not

significantly influence their decisions to increase the level of adoption in water erosion and soil fertility control measures.

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CHAPTER 7: CONCLUSION AND RECOMMENDATIONS

7.1 Introduction

The research was conducted in order to produce knowledge on farmers' perceptions of soil erosion, and their soil conservation measures in the northern part of Taraba State, Nigeria. This was in realization that farmers in the study region cultivate the hill slope site (areas where erosion are more prone) whereas lowland area exists (2 sites of the research focus). To arrive at the results obtained fields transect walk of the study region at different times and villages were undertaken to collect information on farmers' fields. A total of 383 questionnaires were administered to household heads selected randomly from the list of arable crop farmers provided by Taraba State Agricultural Development Programme to solicit for their responses in the region. In addition, in-depth interviews with key informants (individual heads of households, agricultural extension agents, and traditional community agricultural chiefs (locally title *sarkin noma*) was carried out to obtain more information about the same fact and to increase the validity and reliability of data obtained. Descriptive statistical analysis of the Statistical Package for Social Sciences (SPSS 22) software was used to analyze the primary data. The analysis method used descriptive statistics, primarily frequency converted to percentages, in addition to the Chi-square and Spearman correlation analysis. In this chapter, the summary of the findings, conclusions, and recommendations based on the results of the finding are presented.

7.2 Conclusion

This study examines farmers' perception of soil erosion due to water and their soil conservation measures in the northern part of Taraba state, Nigeria. This was in realization that farmers in the study region cultivate the hillslope areas, whereas flatland provided by nature exist. Although, there were widespread researches on on-farm soil

erosion in Nigeria generally, and in the study region, in particular, must of them has focused on quantitative assessment of the magnitude of soil erosion. Very few studies focused attention on the qualitative assessment of soil erosion using farmers' perception of soil erosion and their conservation measures. Moreover, such researches were consistent that water erosion is a serious issue in the study region. Understanding farmers' perceptions of soil erosion and their conservation measures are the most significant social factors that determine the degree of understanding of soil erosion and its effects. Moreover, farmers' decisions to conserve natural resources generally and soil, particularly are largely determined by their perception of the problems and perceived benefits of conservation. Hence, perceiving soil erosion as a problem by farmers is an important determinant of soil conservation. Any conservation program might not be successful without prior understanding and consent of the concerned stakeholders, the farmers. From the results of this research, the following conclusions are made:

The majorities of the farmers are middle age, married, literate and owned the farm holdings. The farmers acquired their land through inheritance; they have a long period of farming experiences and large family size. Hence, farmers reason for cultivating the hillslopes areas, whereas flatland areas exist.

The majorities of the farmers are aware and perceived soil erosion by water and soil fertility depletion as a problem constraining crop production in their farm plots. Furthermore, they farmers were able to identify the different causes of soil erosion in their land based on knowledge they have through farming conditions. The main causes as farmers recognized include the intensity of rainfall, types of soil and erodibility and insufficient and delayed fertilizer. In addition, the farmers can differentiate various indicators, effects, and consequences of water erosion and soil fertility loss using their experiences of identification of associated severity of soil erosion and fertility depletion.

The major factors that the farmers perceived as indicators of soil erosion on their farms are visible signs-rill and gullies erosion and change in soil colour. While, visible signs of reduced farmland sizes, by submerged and drop in yields were the farmers' perceived effects of soil erosion on their farmlands. Furthermore, the majority of the farmers perceived the trend of water erosion increasing and soil fertility declining. High rainfall intensity, deforestation, bush burning, cultivation of marginal areas, and inappropriate soil conservation techniques were farmers' reasons for the increased in the trend of water erosion over the years.

The farmers preferred the hillslopes to flatland areas to avoid animals grazing from destroying their crops, less weed invasion and for historical reasons. It was also discovered during the in-depth interview that the farmers are well aware of the erosion consequences on slopes farmlands than flatland farmlands, but they do not see it as a threat because of the advantages they derive outweigh erosion problems. Hence, this may have been the major cause of cultivating the hill slope while flatland areas exist in this area. However the chief contributing factor in the advancement of farming have been the best practices used by the farmers over generations to sustain agricultural productivity in this region, especially ploughing across the contour, construction of bunds, construction of ridges, and waterways as major water erosion measures and the use of compost and mulching, intercropping, and use of farmyard manure as the most widely used traditional soil fertility improvement measures in the research region.

The extension agents which were to play an important role in providing, facilitating and encouraging local organizations are few in the study region, and extension agents visits and services given to farmers are insufficient, infrequent and irregular.

The finding with respect to the relationship between farmers' adoption of soil conservation measures and their perception of water erosion and fertility depletion as a problem revealed that the farmers who perceive water erosion as a problem on their land

do not adopt significantly ($p < 0.05$) more than do farmers who do not perceive water erosion as a problem. However, farmers who perceive soil fertility depletion as a problem on their land do adopt significantly ($p < 0.05$) more than do farmers who do not perceive fertility depletion as a problem. Based on interviews with farmers, accessibility and better availability of manure as a result of large livestock populations contribute to this high percentage of respondents applying soil fertility measures. Also, the results with respect to the relationship between the trend of water erosion and fertility depletion and their level of adoptions reveal that most farmers in the study area perceive increasing water erosion and declining soil fertility as an increasing problem, however, this perception does not significantly influence their decisions to increase the level of adoption in water erosion and soil fertility control measures.

The biophysical examination of soil erosion should be integrated into future studies to provide empirical evidence of farmers' preference for cultivating hillslope site while there are flatlands. However, the study was limited investigation farmers' perception and conservation due to resource inadequacy and constraints.

7.3 Recommendations

Based on the findings of this study, the following recommendations are put forward.

- i. The biophysical examination of the farmers' fields should be integrated into future studies to provide empirical evidence about the soil fertility status of the cultivated fields. This will provide complementary data for a better understanding of the farmers' preference for cultivating hillslope site while there are flatlands.
- ii. Since money forms the basic bedrock of procurement of necessarily improved inputs such as fertilizer, improved plant varieties, and herbicides. It is also recommended that formal credit through public or private financial institutions

should be provided to farmers in the study area. Thus, this will go a long way in improving the degraded farmlands and hence improving total crop output.

- iii. The government should increase the number of extension agents in the study region. Effective extension advisory services on better and modern method of farming, which will reduce water erosion and conserve soil fertility, needs to be also directed at farmers.
- iv. In order to achieve sustainable soil management, it is suggested that policies and institutional arrangements are needed to encourage intensification of cultivation activities on the flatlands, and discourage uncontrolled extensification of agricultural use on hill slope areas.
- v. Local farmers' organizations with appropriate support and encouragement could facilitate participatory development and help to address on-farm soil erosion and fertility depletion. In this regard, it is recommended that land users association at the village level should be encouraged and strengthens to play a critical role in dealing with soil erosion and soil fertility depletion.

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LIST OF PUBLICATIONS AND PAPER PRESENTED

1. Farmers' perception of soil erosion and their investments in soil conservation measures: Emerging evidence from northern part of Taraba State, Nigeria. *Soil Use and Management*. Soil Use and Management, 33, 163–173, 2017.
2. Exploring Farmers' Local knowledge and Perception of Soil Erosion under Agricultural Lands in the northern part of Taraba State, Nigeria. *International Journal of Tropical Agriculture*. Vol. 33, No. 4, October-December 2015.

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